DEPARTMENT OF THE ARMY CORPS OF ENGINEERS

BEACH EROSION BOARD
OFFICE OF THE CHIEF OF ENGINEERS

SAND BYPASSING AT PORT HUENEME, CALIFORNIA

TECHNICAL MEMORANDUM NO. 92

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MARCH 1957

FOREWORD

One of the possible solutions to the erosion problem commonly occurring downdrift from a jettied entrance, caused by stoppage of passage of the normal drift by the jetty barrier, is periodic replenishment of material on the eroded beach. This material is frequently taken from the accreting area updrift from the jetties. Such a replenishment operation was carried out in the Port Hueneme-Point Mugu, California area in late 1953 and early 1954. Involving a rather novel method of obtaining the material from the accreted area (first dredging a large lagoon in back of the beach, leaving a barrier to serve as protection for the dredge, and then dredging cuts through the barrier), the operation and its results have been observed rather closely. This report details the operation and discusses the results shown by periodic surveys taken after job completion. In general it indicates the method to be successful, but suggests some modifications should any future similar operation be planned.

The report was prepared by Rudolph P. Savage, a Hydraulic Engineer in the Research Division of the Beach Erosion Board, under the general supervision of Joseph M. Caldwell, Chief of the Division. During the time the report was in preparation, Brigadier General Theron D. Weaver was President of the Board. R. O. Eaton was Chief Technical Advisor. The report was edited for publication by A. C. Rayner, Chief of the Project Development Division.

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SAND BYPASSING AT PORT HUENEME, CALIFORNIA

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INTRODUCTION

During the latter part of 1953 and the early part of 1954 a unique sand bypassing operation was carried out at Port Hueneme, California as an interim plan to cope with a severe beach erosion problem. Although sand bypassing (moving sand past an inlet or other shore line barrier to nourish the beaches on the downdrift side of the barrier) is not a new concept(1,2,3,4,5)* this operation was unique because of the method used to bypass the sand. Previous beach restoration or nourishment operations have employed a floating dredge(1) in lagoonal or relatively protected offshore waters or a fixed dredging plant with the sand intake in the surf zone to transfer sand past an inlet. This operation was carried out by a floating dredge operating behind a narrow sand barrier and in the surf zone.

Since this was a new type of operation, many problems arose during both its planning and execution. Knowledge of the solution of these problems and the resultant effects would be profitable in the consideration of any similar operation in the future. This paper presents the cause of the erosion, the original plan, execution, and results of the operation in order that the information obtained may be available for future planning.

DESCRIPTION AND HISTORY OF PORT HUENEME

Port Hueneme is located on the Pacific Coast of California about 65 miles northwest of Los Angeles Harbor and 345 miles south of San Francisco, and lies in the center of the seaward (southwesterly) side of the Oxnard Plain (Plate 1)**. The harbor consists of a dredged basin with an entrance dredged through the beach at a natural salient of the shore known as Point Hueneme. The harbor entrance is protected by two jetties approximately 1,000 feet long constructed to about the 30-foot depth contour. The harbor's seaward entrance which is 1,100 feet wide opens directly into the head of the Hueneme Submarine Canyon (Plate 1).

Port Hueneme Harbor was built by the Oxnard Harbor District during the period 1938 to 1940. As a result of a study of the effects that harbor improvements being considered for Ventura and the port development at Hueneme, California, would have on adjacent shore lines, in 1940 the Shore Protection Board (Beach Erosion Board) concluded that "the recently completed jetties at Hueneme will probably cause extensive accretion

* Numbers in parentheses refer to list of references on page 26.
** Plates included at end of report.

on the upcoast side of the west jetty ultimately advancing the shore line to the outer end of the structure. Serious erosion is expected to occur on the downcoast side of the east jetty". In 1942, the Navy Department acquired the harbor for military purposes.

The beaches adjoining the harbor are divided into two segments by the harbor entrance; the upcoast segment beginning at the west jetty and extending approximately 6.5 miles northwesterly to the Santa Clara River mouth, and the downcoast segment beginning at the east jetty and extending about 8 miles southeasterly to Laguna Point (Plate 1). The upcoast segment has an essentially straight, unbroken beach with no structures. Its entire length is backed by a sand dune area. The downcoast segment consists of a similarly straight unbroken beach with no structures except for a rubble-mound seawall extending eastward 1/2 mile from the east jetty, constructed in 1942-1943 by the Navy Department to protect its property. The easterly beaches of the downcoast segment, beginning at a point approximately 3 miles east of the east jetty and extending past Laguna Point, front the U. S. Naval Air Missile Test Center of Point Mugu, California.

The history of the upcoast segment over the record period of 1855 to 1938 was one of accretion or out-building amounting to a width of 400 feet at the mouth of the Santa Clara River and tapering to 100 feet at Point Hueneme. After completion of the west jetty at Port Hueneme in June 1939, the shore line continued to advance seaward in the vicinity and immediately upcoast of that jetty until late 1953 when the sand by-passing project was initiated.

The history of the downcoast segment during the record period from 1855 to 1938 was one of remarkable stability, the shore line having almost the same position in 1938 as in 1855. Since construction of the jetties at Port Hueneme in 1939, the beaches of the downcoast segment in the immediate vicinity of the east jetty have eroded rapidly where seawalls have been built. In the absence of protective measures to hold the land east of the seawalls, erosion progressed steadily eastward until the whole downcoast segment was threatened with serious erosion.

A study of shore protection and harbor requirements at Port Hueneme was completed by the Corps of Engineers in 1950. This report[6] concluded that a serious erosion problem did exist along the downcoast segment and recommended in part deposition of dredged material to restore and maintain the shore of the downcoast segment. The recommended harbor and shore protection project was authorized by the River and Harbor Act of 1954. In August 1951 the Navy Department, faced with a serious erosion threat to the Mugu Naval Air Missile Test Center, decided to proceed with an interim shore protection project, the planning and execution of which is the subject of this report.

LITTORAL FORCES AND PROCESSES

Winds. The character of the winds at Port Hueneme is shown on Plate 1 by a wind diagram based on observations at the Port Hueneme lighthouse over a 60-year period from 1874 to 1935. This diagram shows that a westerly breeze of 0 to 10 miles per hour prevails about 135 daysa year. About 58 days a year, a northwesterly breeze of the same velocity range prevails. The resultant or average of these two winds is a breeze that prevails 193 days, or more than half of each year in a direction that roughly parallels the axis of Santa Barbara Channel. Easterly and southeasterly winds ranging in velocity from 10 to 55 miles per hour blow a total of 54 days each year, and the average direction is again along the axis of the Santa Barbara Channel. Breezes 0-10 miles an hour blow from other directions approximately 65 days a year and winds of 10-55 miles per hour blow from other directions approximately 53 days a year. Most of the stronger winds are associated with storms in the coastal areas.

Waves. From Plate 1 (inset) it can be seen that the Port Hueneme area is sheltered from waves from some directions by the offshore islands. Unrestricted avenues of wave approach are limited to a total of 70 degrees of azimuth in three sectors: one through the Santa Barbara Channel; one through Santa Cruz Basin west of San Nicolas Island; and one through the passage between San Nicolas and San Clemente Islands. Information given in a report by the Scripps Institution of Oceanography[7] reveals that the predominant wave direction for the Port Hueneme area is northwesterly. During the summer and transition seasons, waves 2 feet or less in height were predicted to occur from this predominant (northwest) direction about 35 percent of the time, and waves 2 to 4 feet in height were predicted to occur from the predominant direction about 20 percent of the time. The waves predicted during the remaining 45 percent of the time consisted of waves 4 to 8 feet high from the northwest, and waves from other directions, mostly north-northwest, west-northwest, and west. During the winter months a higher percentage (57 %) of the waves arrive from directions other than the predominant northwesterly direction, and the percentage of higher waves is somewhat greater. Waves in excess of 8 feet occur each year but are of relatively short duration.

The foregoing wave heights are those that occur in deep water off shore. As the waves approach the shore they are subject to considerable change both in height and direction by refraction over offshore banks and the continental shelf. Because of the east-west alignment of the shore line between Point Conception and Ventura, the waves from the predominant northwest direction are almost entirely screened from the segment of shore line under consideration. Only the more westerly elements of the offshore waves are capable of being propagated through Santa Barbara Channel to its east end at Port Hueneme. These waves are turned by refraction toward the northeast over the broad shelf opposite Port Hueneme and diverge considerably before reaching shore. This divergence of the waves causes a significant reduction in wave height at the shore line, except where irregularities of the ocean floor cause a convergence. Except during the arrival of storm waves, wave heights at Port Hueneme and vicinity seldom exceed 4 feet.

Tides. The mean range of tide along the coastal area from Ventura to Point Mugu is 3.7 feet. The diurnal range, from mean higher high water to mean lower low water, is 5.4 feet. The extreme range is about 10.5 feet.

Littoral Processes. Studies[8] of the movement of littoral drift in the Port Hueneme area have shown that it is preponderantly downcoast (west to east) and that reversals in direction are virtually negligible.

The primary source of littoral material for the Port Hueneme area is the Santa Clara River and its tributaries. Rough estimates based on studies of surface-rock types and run-off rates in the Santa Clara River drainage area, analyzed in the light of known sedimentation rates in nearby reservoirs, indicate that the average annual contribution of littoral material from this source is approximately 1,200,000 cubic yards. This material is brought down the Santa Clara in huge quantities during floods and deposited as a delta at the river mouth. This delta then acts as a stockpile for littoral nourishment during ensuing years. In the past the Santa Clara has apparently supplied an overabundance of material to its adjoining beaches, since these beaches now contain enough littoral material to maintain the present littoral drift rate for many years. It is probable that some littoral material also reaches the area from the beaches west of the Santa Clara River delta. The measured rate of littoral material bypassed at Santa Barbara (24 miles west of the Santa Clara) has averaged about 300,000 cubic yards a year over a 17-year period (1929 to 1946). Although some losses may occur between Santa Barbara and the Santa Clara River, they are probably largely replaced by the contributions of local coastal streams including the Ventura River.

Analysis of beach and offshore profiles of surveys made in 1938 and 1948 indicated that the accretion area upcoast from the west jetty at Port Hueneme has grown at the rate of about 400,000 cubic yards a year and that material had moved off the beach downcoast at an average of about 1,200,000 cubic yards a year. Because losses by wind deflation are believed to be small in comparison to the indicated movement by waves and currents, they were neglected in this analysis. Studies of contour changes in various submarine canyons along the California coast have indicated that sloughing of material deposited on the steeper slopes occurs with frequent regularity. The canyon heads therefore never fill completely but the accumulations in the heads of the canyons are intermittently flushed seaward under the influence of some force (possibly earth tremors) not understood at this time. Considering that the downcoast beaches were stable during the period of record before harbor construction and began eroding at the rate of 1,200,000 cubic yards a year after harbor construction, it would appear that an average of

1,200,000 cubic yards of material was passing Point Hueneme each year. Considering this, and the accumulation of 400,000 cubic yards a year above the north jetty, it would appear that as much as 800,000 cubic yards of material in downcoast transport may be shunted into the Hueneme canyon head annually by the presence of the west jetty. Since there are no quantitative data on either deflation losses or accumulations in the canyon, quantitative distribution of the missing material must remain in doubt.

Later volumetric computations[9] from surveys made in 1948 and 1952 show that material was moving off the downcoast beaches at an annual rate of approximately 1,100,000 cubic yards, which tends to substantiate the earlier measurements.

PLANS FOR SAND BYPASSING

In August 1951, the Navy Department requested that the Corps of Engineers prepare plans, specifications, and cost estimates for interim erosion protection measures for the Mugu Naval Air Missile Test Center. Of four plans considered in the report[9], the recommended plan provided for hydraulic dredging by floating plant and pumping 4 million cubic yards of material from the Silver Strand accretion area just upcoast of the Hueneme west jetty onto the downcoast beaches. A total of 500,000 cubic yards of this material was to be placed on the secondary feeder beach in the vicinity of Arnold Road (Plate 1) at the west end of the Mugu Naval Air Missile Test Center to begin immediate nourishment of the beaches fronting that property, and the remaining material (3,500,000 cubic yards) was to be placed on the primary feeder beach just east of the Hueneme east jetty. It was expected that material from the primary feeder beach would be moved downcoast and begin nourishment of the Test Center beaches upon depletion of the 500,000 cubic yards of material placed on the secondary feeder beach.

The dredging operation was to be carried out in two phases. During phase 1, an estimated 1,400,000 cubic yards of material would be pumped from Silver Strand Beach by dredging a lagoon in the accretion area to a depth of 12 feet*; the landward edge of the lagoon was to be 250 feet seaward of the private property line. Entry to the Phase 1 dredging area was to be made through the beach inside the jetty and the dredging operation was to be carried out behind a protective beach ridge or barrier consisting of the natural berm at elevation about +10 feet which was to be left on the seaward side of the dredging area. During phase 2, an estimated 2,600,000 cubic yards of material would be dredged by removing the protective barrier between the lagoon and the 10-foot depth contour in the ocean to an average depth of 22.5 feet.

The recommended plan had two desirable features. First, it would give immediate protection to the Test Center beaches, and second, it would restore the impounding capacity of the west jetty, thus providing

* All depths and elevations are referred to the plane of mean lower low water

a trap for the material moving into the area from upcoast and preventing, at least temporarily, further loss of material into the Hueneme Canyon head and movement of material into the harbor entrance.

The disadvantage of the plan was that during the phase 2 dredging, the dredge would be operating in and near the surf zone and would be exposed to open sea wave action for a large part of the dredging time. For this reason, the dredging in phase 2 was to be carried out in separate cuts 200 feet wide, 25 feet deep,and on 400-foot centers, as shown in the plan of the dredging area on Plate 3. It was felt that the banks between the cuts would then slump into the cuts until their highest elevation became -15 feet, leaving a mean depth in the phase 2 area of 22.5 feet. This dredging procedure was expected to alleviate to some extent the undesirable exposure of the dredge to direct wave action by having the dredge operate in a relatively deep channel between two sand banks, where it would be protected initially by the shoal at the seaward end of the cut and later by favorable wave refraction within the cut.

It was recognized that the production rate in phase 2 would be difficult to estimate, since at times the dredge might be forced to suspend operations because of unfavorable wave conditions. Therefore it was recommended that this portion of the work be carried out on a rental basis, although the work in phase 1 was to be carried out by contract on a unit price basis. A contract was awarded to the Standard Dredging Corporation by the Los Angeles District of the Corps of Engineers and work was started in August 1953.

Concurrent with the planning of the dredging project, the Beach Erosion Board planned a series of observations to be made in cooperation with the Los Angeles District and the Navy Department before, during, and after the dredging operation. These observations were to be made to further the knowledge of sand bypassing and littoral processes in general. Included in the proposed observations were:

a. Hydrographic surveys of the complete area including a preliminary survey, surveys as often as possible during the dredging operation, a final survey immediately after dredging, and surveys at 6 months, 1, 2, 3, and 4 years after completion of the dredging;

b. Aerial photographs of the area as often as possible during the operation and in the period immediately following the operation; and

c. Measurements of the wave period and height to be made for 15-minute durations every 2 or 3 hours during and after the dredging operation. To do this, the Beach Erosion Board proposed the installation of a wave gage just seaward of the west end of the dredging area in 20 to 30 feet of water.

It was felt that this series of observations would be of considerable aid in evaluating the dredging operation and its effects.

SAND BYPASSING OPERATION

The contractor elected to use an optional entry route into the phase 1 area (see Plate 2) from the open sea just west of the west jetty. Since the dredge could not dredge itself into that area directly from the ocean, a hole was dug in the area with bulldozers and a dragline. A small dredge, the "Beaver", was then brought overland and placed in the hole. The "Beaver" started the phase 1 dredging on September 1, 1953, pumpimg sand across the harbor entrance onto the primary feeder beach through a submerged pipe. A pump, installed in the harbor, pumped water into the hole to replenish that pumped out by the dredge and thereby kept the dredge afloat. The "Beaver" first dredged an area 300 by 600 feet to -11 feet and then dredged a channel to -5 feet to the open sea along the optional entry route. This operation was completed on October 5, 1953 and the dredge "Los Angeles No. 2" was towed into the phase 1 area the next day. Mobilization of pontoons and discharge line was delayed by rough seas during the period. Dredging started on October 15th, the material being pumped to the primary feeder beach. Pumping to the secondary feeder beach at Arnold Road began on October 21st after a booster pump had been installed in the discharge line. Meanwhile, the rough seas and extreme high tides from October 7-10 had eroded the original sand ridge between the phase 1 area and the sea to the elevation of mean lower low water from station 0 to station 8 (Plate 4), as a direct result of the opening made through the beach for entry of the dredge. On October 27th, land equipment started hauling sand from the phase 1 area to build a dike to elevation +10 feet to replace the eroded ridge between the phase 1 lagoon and the sea. This operation was completed on November 3, 1953.

Pumping continued from the phase 1 area to the secondary feeder beach until February 2, 1954, except during breakdowns of the booster pump. During these breakdowns, material was pumped to the primary feeder beach. During November 1953 a second pump was installed in the harbor to maintain the water level in the lagoon. Pumping to the secondary feeder beach was completed on February 2nd when a total of 519,000 cubic yards of material had been deposited on that beach.

During December 1953 it was decided that the project depth in the lagoon could safely be increased to 18 feet in order to get as much material as possible without endangering private property behind the dredged area. The phase 1 area was dredged accordingly.

Dredging in the lagoon continued without incident until February 25, 1954, when it was found that the two pumps previously installed to supply water were not adequate. A drop in the water level in the lagoon to -6 feet delayed dredging operations for 40 hours. The contractor therefore breached the protective barrier in cut 1 (Plate 3) to allow water from the sea to fill the lagoon. The water level was thus raised to +3.5 feet, but before the breach could be closed, wave action began eroding the barrier. The phase 1 dredging was completed on the 27th of February, a total of 1,187,483 cubic yards of the planned 1,400,000 cubic yards of material having been pumped from that area.

Coincident with the beginning of the phase 2 dredging on February 27th, an attempt was begun to hold the eroding barrier by operating a dragline with a 2½-cubic yard bucket on the end of the barrier just east of cut 1. This operation reduced the loss of the barrier from 100 to 60 feet a day.

The phase 2 dredging was started according to plan, the first cut being made perpendicular to the barrier in the position shown as cut 1 on Plate 3. In the two days between breaching the ridge on February 25 and initiation of phase 2 dredging on February 27, approximately 200 feet of the barrier in the cut 1 area were eroded to an elevation of about +3 feet. As the dredge progressed seaward from the lagoon its exposure to waves increased. Since all the waves were essentially parallel to the shore line by the time they reached the dredge, the dredge was taking the waves directly on its bow with the wave crests perpendicular to its centerline. This gage the dredge a fore-and-aft rocking motion which broke its quarter wires and three sections of pipe adjoining the dredge. On March 22, 1954, the direction of dredging was changed to due west, or at an angle of approximately 30 degrees to the original cut. This changed the angle of the dredge to the approaching waves and thus the motion of the dredge. Instead of having only a fore-and-aft rocking motion, the dredge then rolled more from side to side. Also, during a major part of the dredging time in each cut, the dredge and attendant pipe line were in the lee of the barrier. It was also decided to dredge the ridges between the original proposed cuts to obtain as much material as possible. This decision was prompted by the realization that dredging seaward of the mean lower low water line would be very difficult, and that the total amount of material available would be considerably reduced unless the intervening ridges were also dredged. Thus, the general procedure in the phase 2 dredging was to dredge in a due west direction which was at an angle to the originally planned cuts, and to dredge the dike in its entirety, starting from its northwest end while trying to maintain the uncut portion of the barrier with land equipment. Generally, the ridge had been eroded to an elevation of about +3 feet at each new cut and therefore the complete barrier stub up to +10 feet was not available for dredging. Profiles of phases 1 and 2 as actually dredged are shown on Plates 7 and 8.

Dredging continued in phase 2 until June 17, 1954. At that time, the barrier was too short to provide adequate shelter for the dredging plant in rough weather, and it was feared that the entire plant might be lost.

At the conclusion of the bypassing operation, a total of 2,032,703 cubic yards of sand had been pumped during both phases. A breakdown of the material pumped and its disposition is as follows:

Phase 1

To secondary feeder beach	519,073 cubic yards
To primary feeder beach	668,410 cubic yards
Total	1,187,483 cubic yards

Phase 2

To primary feeder beach	845,220 cubic yards
Grand Total	2,032,703 cubic yards

Thus, the material actually pumped was almost 2,000,000 cubic yards less than the originally hoped for 4,000,000 cubic yards.

The observation program planned by the Beach Erosion Board was carried out, but not as fully as had originally been anticipated. A preliminary hydrographic survey, periodic partial hydrographic surveys during the dredging, and a final hydrographic survey were made by the Los Angeles District. Another partial hydrographic survey was made in April 1954, and a complete survey was made in June 1955. Aerial photographs were taken by the Navy Department periodically, both during and after the operation. Measurements of wave characteristics began on April 7, 1954 and have continued, except for short periods when the gage was inoperative.

DISCUSSION OF THE DREDGING OPERATION

A summary of a part of the observational program during the phase 2 operations is shown in Figures 1a - 1d. The dredging information was taken from the dredge inspector's report and the tidal information was supplied by the Los Angeles District. The wave period information was obtained from a pressure type wave gage located as shown on Plate 2 and the wave heights were obtained by observation at the dredge. The various types of dredge time are defined as follows:

a. Operating time - time that the dredge was actually pumping sand.

b. Non-effective time - time involved in moving the dredge or in other activities essential to the operation of the dredge other than actual pumping.

c. Lost time - time lost because of breakdowns.

d. Pay-lay time - time lost because of rough weather or rough seas (phase 2 only). During such times, the dredge stopped dredging and pulled back behind the protective barrier.

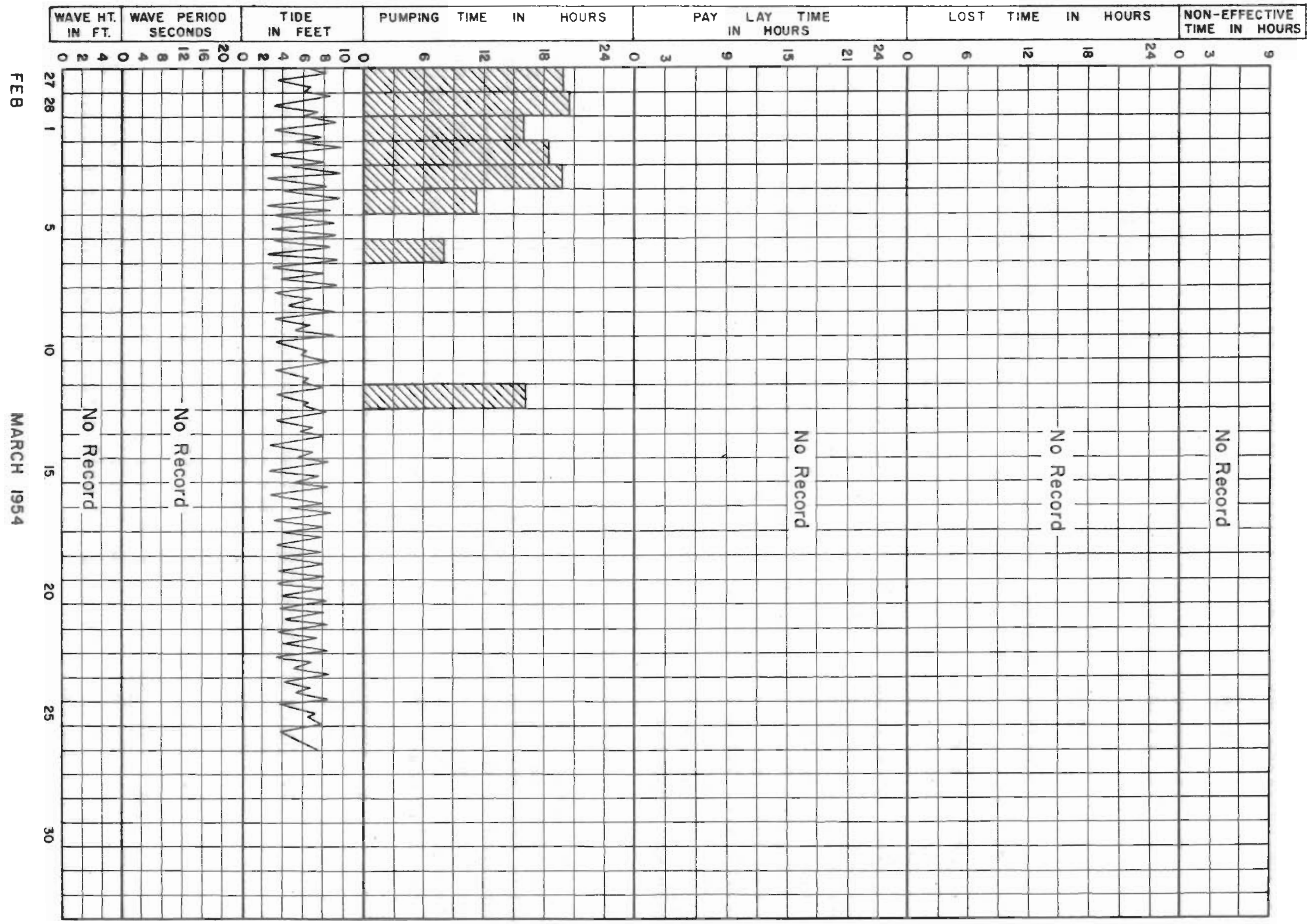

FIGURE 1a. TIDE, WAVE, AND DREDGE-OPERATION DATA.

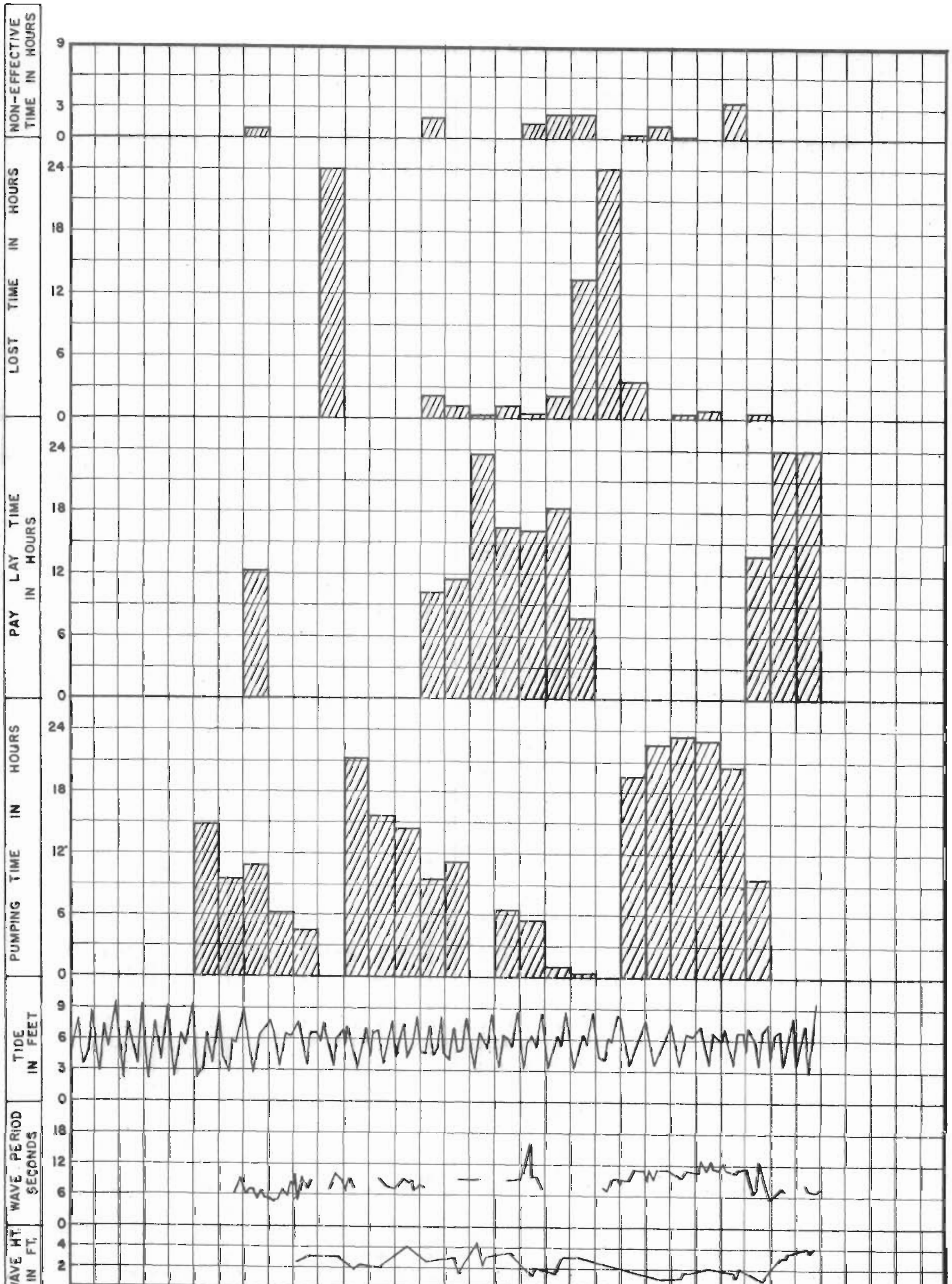

FIGURE Ib. TIDE, WAVE, AND DREDGE-OPERATION DATA.

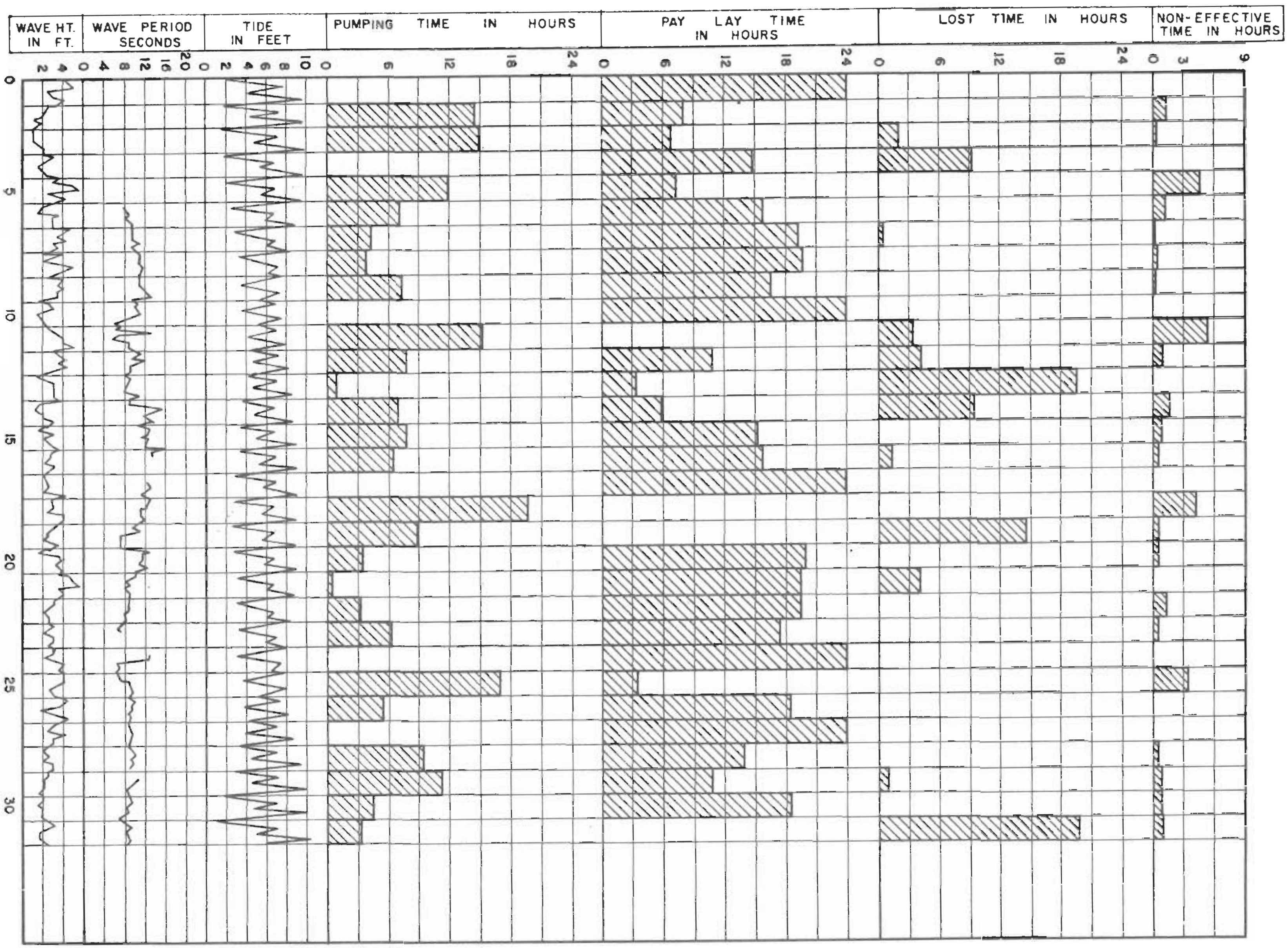

FIGURE Ic. TIDE, WAVE, AND DREDGE-OPERATION DATA.

MAY 1954

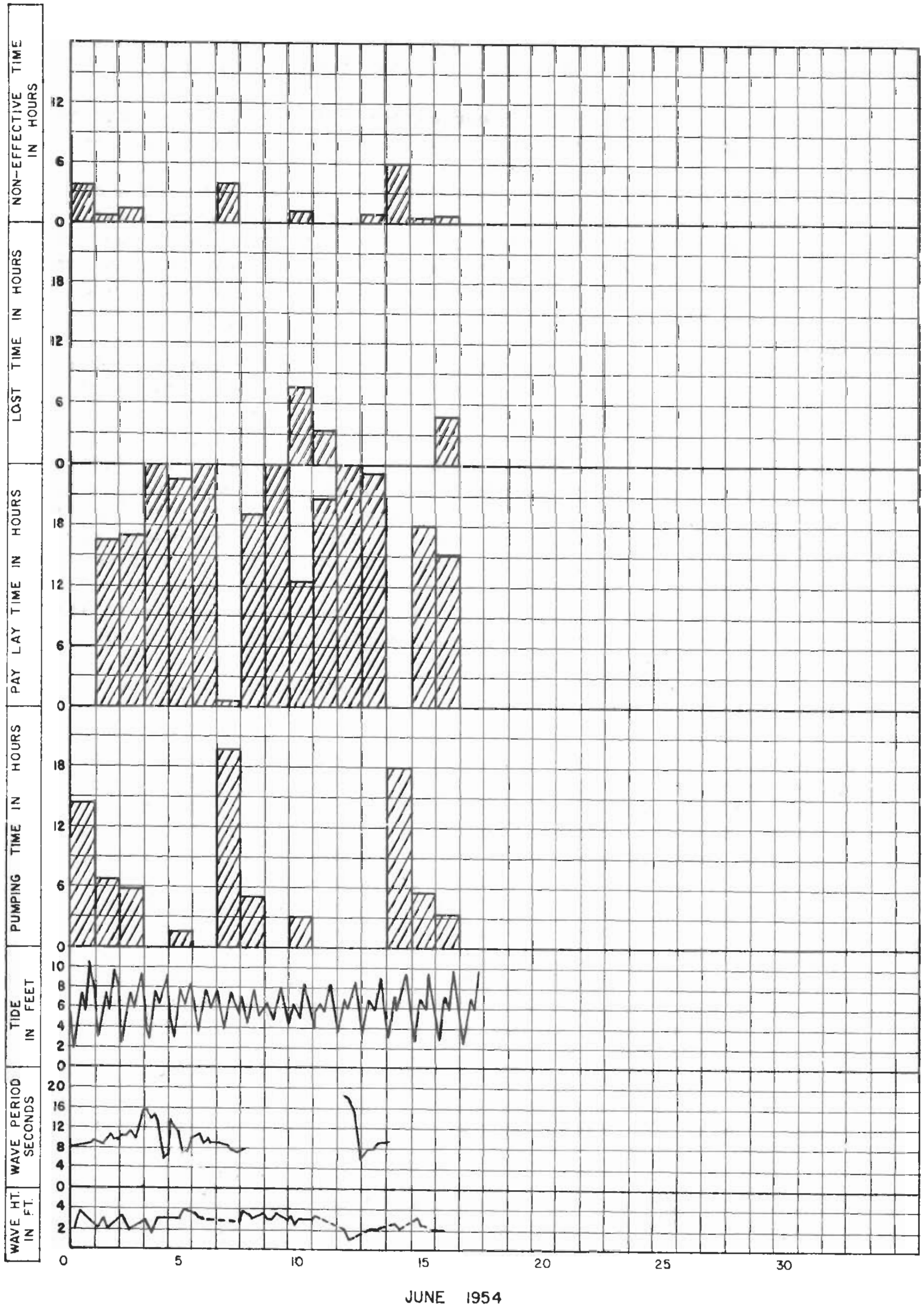

FIGURE 1d. TIDE, WAVE, AND DREDGE-OPERATION DATA.

All of the breaks in the record in Figure 1 were either periods of no record or periods for which records were no longer available.

No correlation is apparent between either the pay-lay or operating time and the wave and tide conditions, probably because no consideration was given to the degree of exposure of the dredge. Apparently dredging could be carried out under more adverse conditions when a cut was first started than near the end, since at the beginning of a cut the dredge was shielded by the barrier. As the cut progressed, exposure of the dredge became greater and only the least violent wave conditions could be tolerated. This exposure factor could not be determined and probably explains the lack of correlation.

Apparently, conditions permitting, it would have been more desirable to make entry into the phase 1 area via the originally proposed entry route (Plate 2) for two reasons. First, since there is very little wave action in the harbor, the entry route could have been left open, eliminating the difficulty of maintaining the water level in the lagoon. Second, no opening and resultant instability would have been made in the protective ridge, eliminating the loss of time in mobilizing the dredging plant and the effort required to hold the barrier. Consequently, in planning future operations of this type, advantage should be taken of any sheltered water body providing a feasible entry route. The feasibility of an operation carried out in the same manner and with similar equipment in an area of heavy wave action in which entry must be made from the sea is seriously doubted. In areas with mild wave action, entrance from the sea would probably be feasible, but a sheltered entry route should be preferred.

On the basis of the difficulties and risks involved in the phase 2 dredging, it appears that future operations of that type will not be feasible unless some protection is provided or unless anticipated wave action is very mild. If an operation is to be repeated several times over a period of years, a breakwater may be economically justifiable, but in view of the costs of breakwaters, it would be very difficult to justify one for a single operation. Under such circumstances, (i.e. a single operation under heavy wave conditions) it would appear to be advisable to dredge - from inside - as much of the barrier as possible without undue risk of a breakthrough. A single relatively wide cut, or a few cuts at intervals beginning at the updrift end could then be quickly made across the dike taking full advantage of calm weather periods. Judging from the results of this Hueneme operation, the remainder of the barrier would than quickly erode into the dredged lagoon with very slight chance of closure of the cut-through. With the ridge eroded, the dredged lagoon would provide a trap for future littoral drift.

It should be noted that these conclusions are drawn from an operation carried out in an area where the littoral transport is almost entirely in one direction with only slight reversals. Application of such conclusions in areas where reversals in direction of littoral transport are frequent and of long duration may not be justified, especially with respect to making the initial cut across the updrift end of the barrier. In this respect, however, it should be noted that when the Hueneme operation was initiated and the dredge entrance cut was made on the downdrift end of the barrier, erosion thereof also proceeded very rapidly indicating that the conclusions reached here might well apply in an area where littoral drift reversals are common.

From the results of this operation, it appears that the landward edge of the lagoon could have been moved at least 50 feet closer to the private property line without resultant damage to private property. This is based on the fact that at no time during or after the operation did erosion or slope stabilization cause the shore edge to approach nearer to the private property line than 80 feet after the lagoon had been dredged to within 250 feet of the private property line and to a depth of 18 feet. Therefore, for this operation, as it was actually performed, a distance of 200 feet between the dredging area and private property would have been safe. There are indications, however, that if phase 2 had been performed as originally planned, i.e., to an average depth of 22.5 feet, the shore line adjustment would have reached a point nearer the private property line.

In future operations of this type where private property behind the dredging area is a consideration, a balance between the depths in phase 1 and the distance between the phase 1 dredging and private property will have to be reached. This balance may be obtained by using the before-dredging beach profiles in the area and the volume to be left for phase 2 which will eventually slump or move into the lagoon to determine the volume which must be left between the phase 1 dredging and private property to provide adequate protection for private property. This volume can then be separated into distance between the dredging and private property and depth, taking full cognizance of the before-dredging beach profiles and allowing a safety factor. The prevailing rate of littoral transport may also enter into these calculations since this is a potential source of sand supply to the area, but since that rate may vary considerably with time or season, it is not a dependable factor for use over short time periods.

BEACH AND NEARSHORE ADJUSTMENTS DURING AND SINCE THE BYPASSING OPERATION

The beach and nearshore adjustments during and since the dredging operation, as revealed by surveys and aerial photographs, are shown in Figures 2 to 6 inclusive; Plates 4, 5, and 6; and Tables 1 and 2. The figures are overlays from vertical aerial photographs taken during the dredging and at intervals after the dredging. Plates 4, 5 and 6 are summaries in contour form of surveys taken before dredging started (October 1953), immediately after the dredging operation (June 1954), and one year after dredging (June 1955). Tables 1 and 2 are summaries of the volumetric changes of the beach in the intervals between the surveys. In Table 2 the volume changes for each pair of June 1954 to June 1955 profiles are given in two parts,one from the base line to the -12 foot contour, and one between the -12 and -24-foot contours. The total volume between each contour pair, and the cumulative volumes for all contour pairs are given as well.

Consideration of Table 1, which deals with the upcoast or dredging area reveals that approximately 162,000 cubic yards of material moved into the dredging area between October 1953 and June 1954. This is indicated by the fact that while approximately 2,033,000 cubic yards of material were pumped from the dredged area in the period from October 1953 to June 1954, surveys covering that period show a loss of approximately 1,871,000 cubic yards. The probable explanation is that the littoral drift from the west moved into the phase 1 area after the first cut was made in phase 2 (February 27, 1953); and thus represents the littoral drift for a period of approximately three months. This would correspond to an annual rate of 648,000 cubic yards, which is about half the estimate given earlier.

From June 1954 to June 1955, approximately 812,000 cubic yards of material moved into the dredged area bringing the total accumulation to 974,000 cubic yards over a period of one and one-fourth years. Such a littoral transport rate is considerably less than the 1,200,000 cubic yards a year previously estimated, but it is highly probable that material was again being shunted into Hueneme Canyon before the end of this period. Based on this yearly rate, the dredged area should be completely refilled before the end of 1957 except that portion above high water where the waves transport sand only during storms.

It should be noted that no appreciable bar formed between the phase 1 lagoon and the sea even though the phase 2 cuts were dredged neither as deep nor as far seaward as originally planned, and that the filling of the dredged area appears to be proceeding essentially as anticipated.

Consideration of Table 2 which deals with the downcoast segment should be tempered with the realization that the profile spacing is inadequate for accurate volumetric computations, since the spacing between several of the profiles is in the order of 2000 feet and in one instance there is a 4,000-foot spacing (between 16E and 20E). However, analysis of the data as given in Table 2 reveals that a portion of the littoral material apparently moved from the primary feeder beach to a point very near the secondary feeder beach in less than a year. This conclusion is based on the fact that the only survey range between the primary and secondary beaches to show a loss during the September 1953 to June 1954 interval was the range immediately updrift from the secondary feeder beach. Therefore, a portion of the material placed on the primary feeder beach in September 1954 apparently moved to range 20E, a distance of approximately 2.5 miles in ten months.

+ (or no sign) Accretion to beach
- Erosion of beach

TABLE 1

PORT HUENEME - UPCOAST AREA

Range Interval	Distance between ranges (ft.)	October 1953 to June 1954 Vol. Yds.[3]	October 1953 to June 1954 Cum. Vol. Yds.[3]	June 1954 to June 1955 Vol. Yds.[3]	June 1954 to June 1955 Cum. Vol. Yds.[3]	October 1953 to June 1955 Vol. Yds.[3]	October 1953 to June 1955 Cum. Vol. Yds.[3]
0- 2	200	- 68,190	- 68,190	28,600	28,600	- 39,590	- 39,590
2- 5	300	-142,530	- 210,720	70,560	99,160	- 71,970	- 111,560
5-12	700	-399,100	- 609,820	203,170	302,330	-195,930	- 307,490
12-15	300	-155,750	- 765,570	79,280	381,610	- 76,470	- 383,960
15-18	300	-129,000	- 894,570	55,500	437,110	- 73,500	- 457,460
18-20	200	- 75,980	- 970,550	33,070	470,180	- 42,910	- 500,370
20-24	400	-160,510	-1,131,060	58,830	529,010	-101,680	- 602,050
24-28	400	-211,430	-1,342,490	97,580	626,590	-113,850	- 715,900
28-32	400	-221,750	-1,564,240	113,040	739,630	-108,710	- 824,610
32-35	300	-125,470	-1,689,710	47,690	787,320	- 77,780	- 902,390
35-38	300	- 91,920	-1,781,630	13,860	801,180	- 78,060	- 980,450
38-42	400	- 89,600	-1,871,230	1,040	802,220	- 88,560	-1,069,010
42-46	400			10,180	812,400		

TABLE 2

PORT HUENEME - VOLUME CHANGES IN DOWNCOAST AREA

(All volumes given in cubic yards)

Range Interval	Distance Between ranges (ft. along baseline)	Sept. 1953 to June 1954 Baseline to -24 ft.	Sept. 1953 to June 1954 Cum. total baseline to -24 ft.	June 1954 to June 1955 Baseline to -12 ft.	June 1954 to June 1955 -12 ft. to -24 ft.	June 1954 to June 1955 Total baseline to -24 ft.	June 1954 to June 1955 Cum. total baseline to -24 ft.	Cum. Total of Dredged Sand remaining on beach, 6/55
4E-6E	510	98,680	98,680	- 76,020	- 7,790	- 83,810	- 83,810	14,870
6E-8E	1,000	239,780	338,460	-194,710	- 19,060	-213,770	-297,580	40,880
8E-10E	1,422	204,980	543,440	-109,650	- 55,530	-165,180	-462,760	80,680
10E-10BE	605	67,660	611,100	- 56,960	- 10,350	- 67,310	-530,070	81,030
10BE-11E	908	147,740	758,840	-156,380	+ 3,080	-153,300	-683,370	75,470
11E-12AE	1,118	185,980	944,820	- 85,560	- 19,730	-105,290	-788,660	156,650
12AE-13E	1,280	78,050	1,022,870	+ 3,770	- 6,910	- 3,140	-791,800	231,070
13E-14E	1,000	99,730	1,122,600	+ 49,140	+ 33,000	+ 82,140	-709,660	412,940
14E-16E	2,075	108,260	1,230,860	+248,400	+ 95,910	+344,310	-365,350	865,510
16E-20E	3,985	59,400	1,290,260	+278,380	+ 25,660	+304,040	- 61,310	1,228,950
20E-22E	2,246	-22,820	1,267,440	- 50,250	- 39,770	- 90,020	-151,330	1,116,110
22E-22EA	1,533	41,110	1,308,550	- 83,340	- 43,300	-126,640	-277,970	1,030,580
22EA-22E-1	1,533	150,570	1,459,120	- 71,670	- 24,890	- 96,560	-374,530	1,084,590
22E-1-23E	1,825	171,480	1,630,600	- 8,090	+ 16,480	+ 8,390	-366,140	1,264,460
23E-23E-5	2,342	67,170	1,697,770	- 35,830	0	- 35,830	-401,970	1,295,800
23E-5-23E-7	1,698			- 33,600	+ 55,760	+ 22,160	-379,810	
23E-7-24E10	2,722	No survey		- 54,300	+105,270	+ 50,970	-328,840	
24E10-25E	2,396			- 70,440	+ 39,520	- 30,920	-359,760	
25E-25E14	1,987	for		- 64,680	+ 11,700	- 52,980	-412,740	
25E14-25E16	2,285	Sept., 1953		- 54,580	+ 9,340	- 45,240	-457,980	
25E16-26E18	2,404			- 3,460	+ 45,980	+ 42,520	-415,470	

Table 2 also shows that approximately 415,500 cubic yards of material moved out of that portion of the downcoast shore line covered by the surveys during the year from June 1954 to June 1955. No estimate of comparable material movement between September 1953 and June 1954 is available because the 1953-survey extended only to range No. 23E-5. The movement of 415,000 cubic yards per year from 1954 to June 1955 is considerably less than the 1,200,000 cubic yards per year previously estimated, but may be misleading since it is based on a period of only one year (see Addendum).

Figures 2 to 6, inclusive, are overlays from aerial mosaics of the Port Hueneme area. Figure 2 was traced from a mosaic composed from photographs taken in February 1954 at which time dredging was in progress in phase 1. All the material to be pumped to the secondary feeder beach (516,000 cubic yards) had been pumped, and material was being placed on the primary feeder beach.

Figures 3 and 4 are from photographs taken during the phase 2 dredging; Figure 3 in April 1954 soon after phase 2 dredging started, and Figure 4 in June 1954 just before dredging ceased. At this time (June 1954) the primary feeder beach was about 300 feet wide.

Figures 5 and 6 are from photographs taken after dredging; Figure 5 approximately four months after dredging ceased and Figure 6 ten months later (i.e., 14 months after dredging).

From Figures 4 and 5 it can be seen that a major portion of the material on the primary feeder beach had moved downcoast in this four-month period. In Figure 6 it appears that the focal point of erosion has shifted downcoast to a point beyond the end of the seawall. This is substantiated by the contours on Plate 5 and the last column in Table 2 which shows the cumulative total of the bypassed sand remaining on the beach in June 1955. It can be seen that of the original 1,500,000 cubic yards pumped to the primary feeder beach, only 75,000 cubic yards, or 1/20 of the original volume, remains between range 11-E and the harbor entrance, a distance of approximately one mile. Assuming that this denudation started immediately on initiation of pumping to the primary feeder beach (September 1953) and continued until the June 1955-survey, movement of the major part of the beach fill from the primary feeder beach to range 11-E took place in less than two years and constitutes a one-mile movement of the focal point of erosion in less than two years.

The following indices of the annual littoral transport rate at Port Hueneme are available from this study, but all should be treated with caution, since the data cover a period of approximately one year:

a. A total of 974,000 cubic yards of material moved into the dredged area in 1-1/4 years giving an annual rate of approximately 780,000 cubic yards. This figure is probably low since it is very probable that material was again being shunted into Hueneme Canyon before the end of this period.

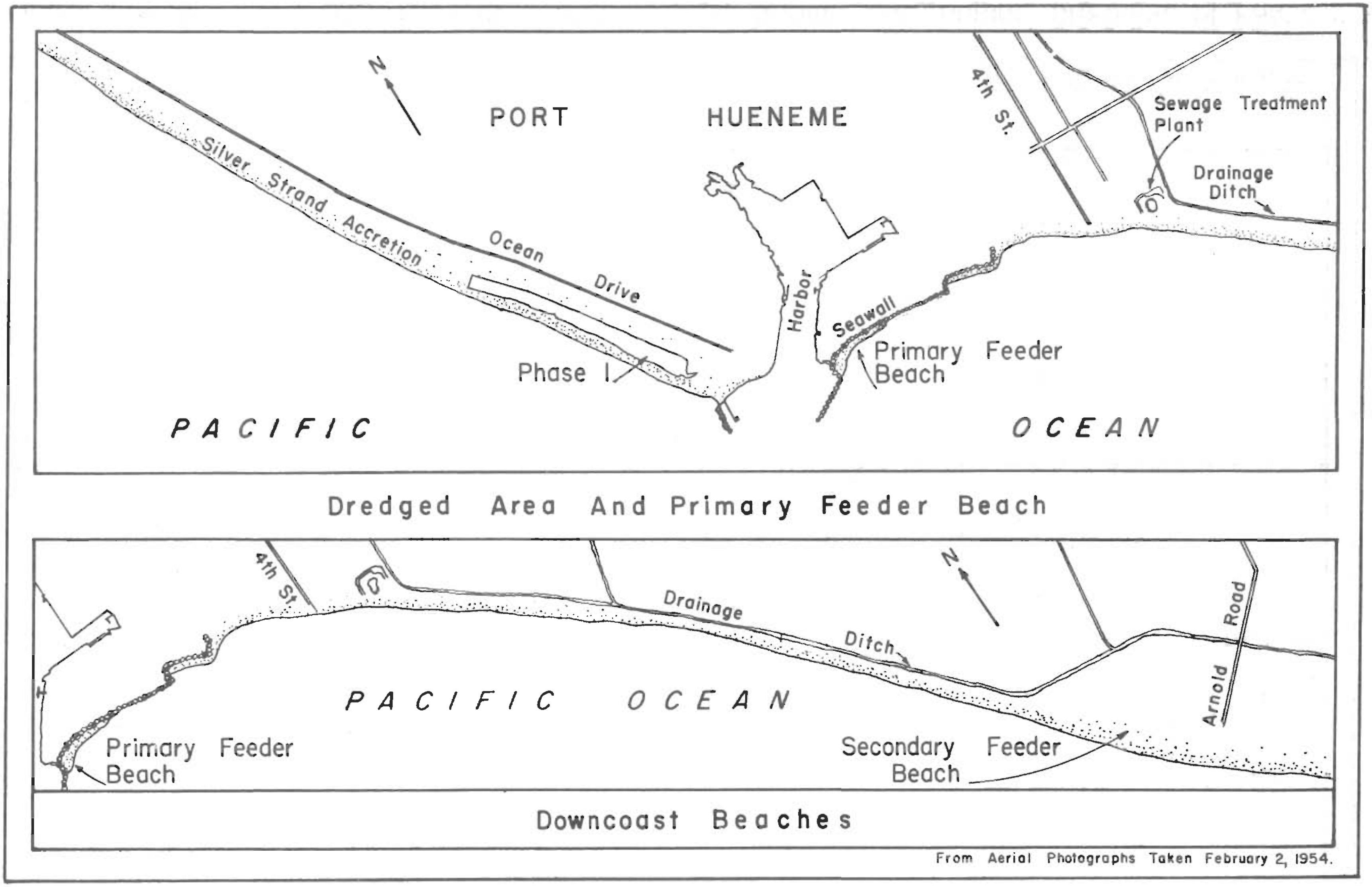

FIGURE 2. PORT HUENEME, CALIFORNIA. APPROXIMATE SHORE LINE DURING DREDGING IN PHASE I.

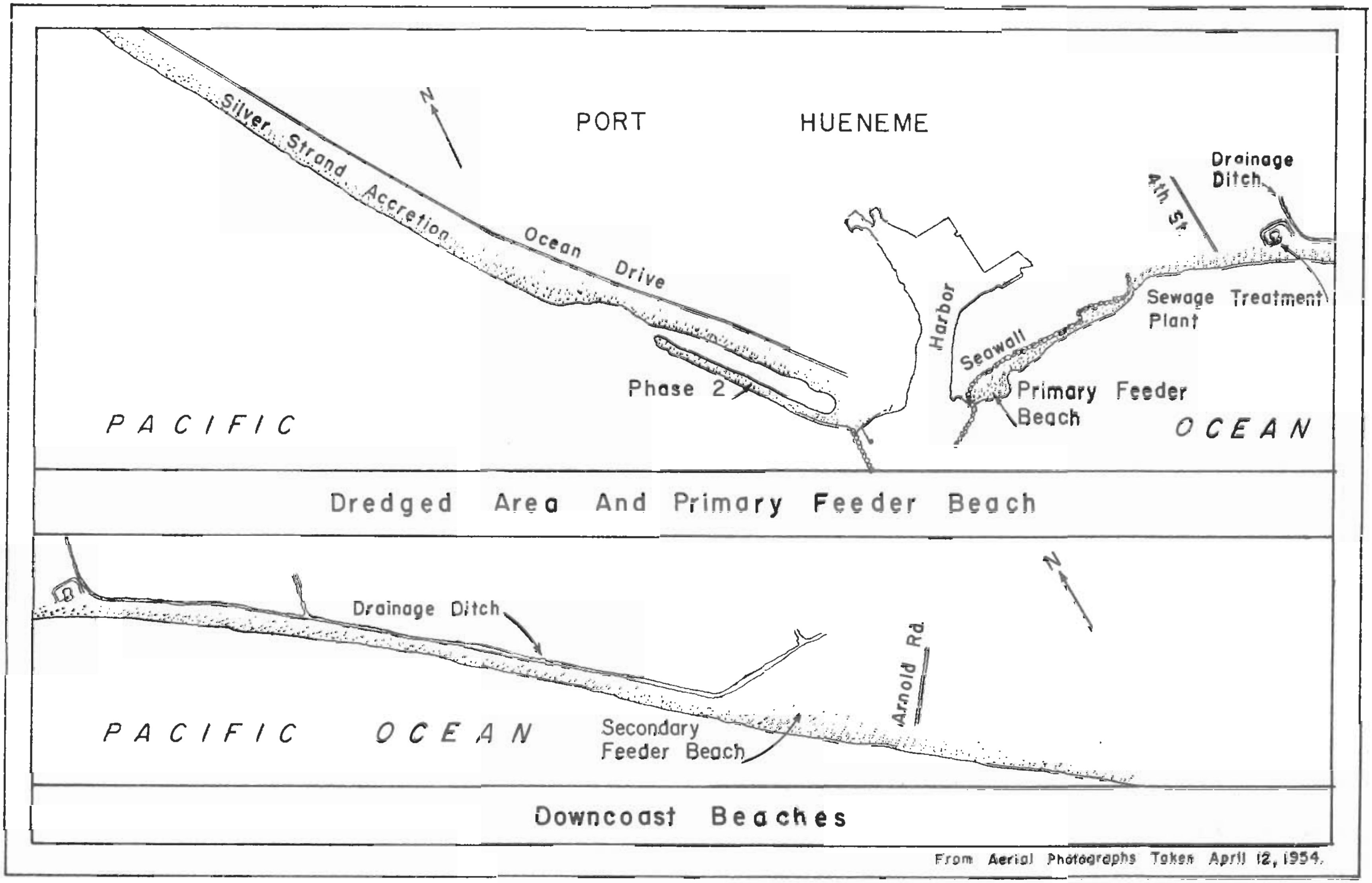

FIGURE 3. PORT HUENEME, CALIFORNIA. APPROXIMATE SHORE LINE DURING DREDGING IN PHASE 2.

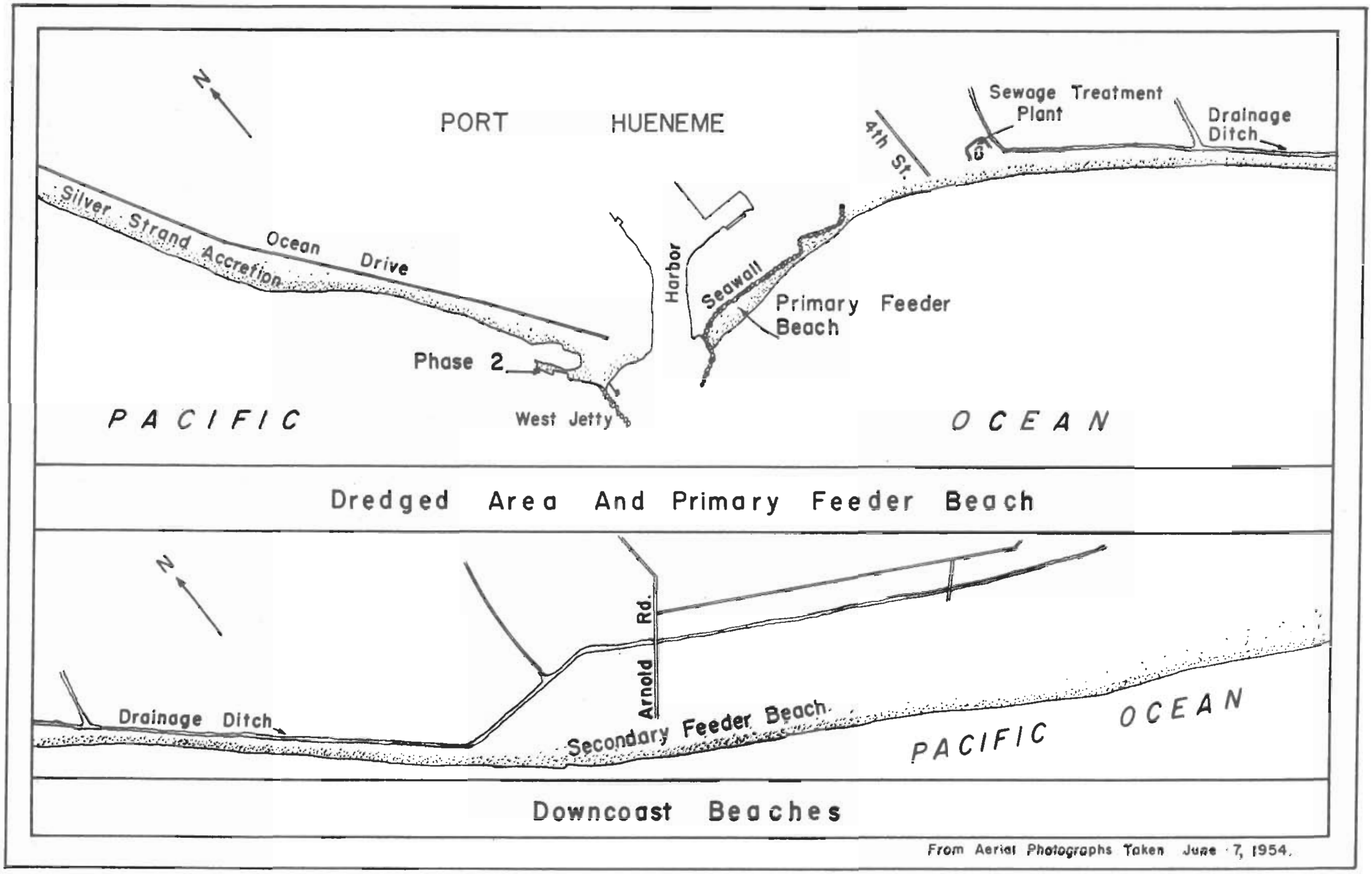

FIGURE 4. PORT HUENEME, CALIFORNIA. APPROXIMATE SHORE LINE DURING DREDGING IN PHASE 2.

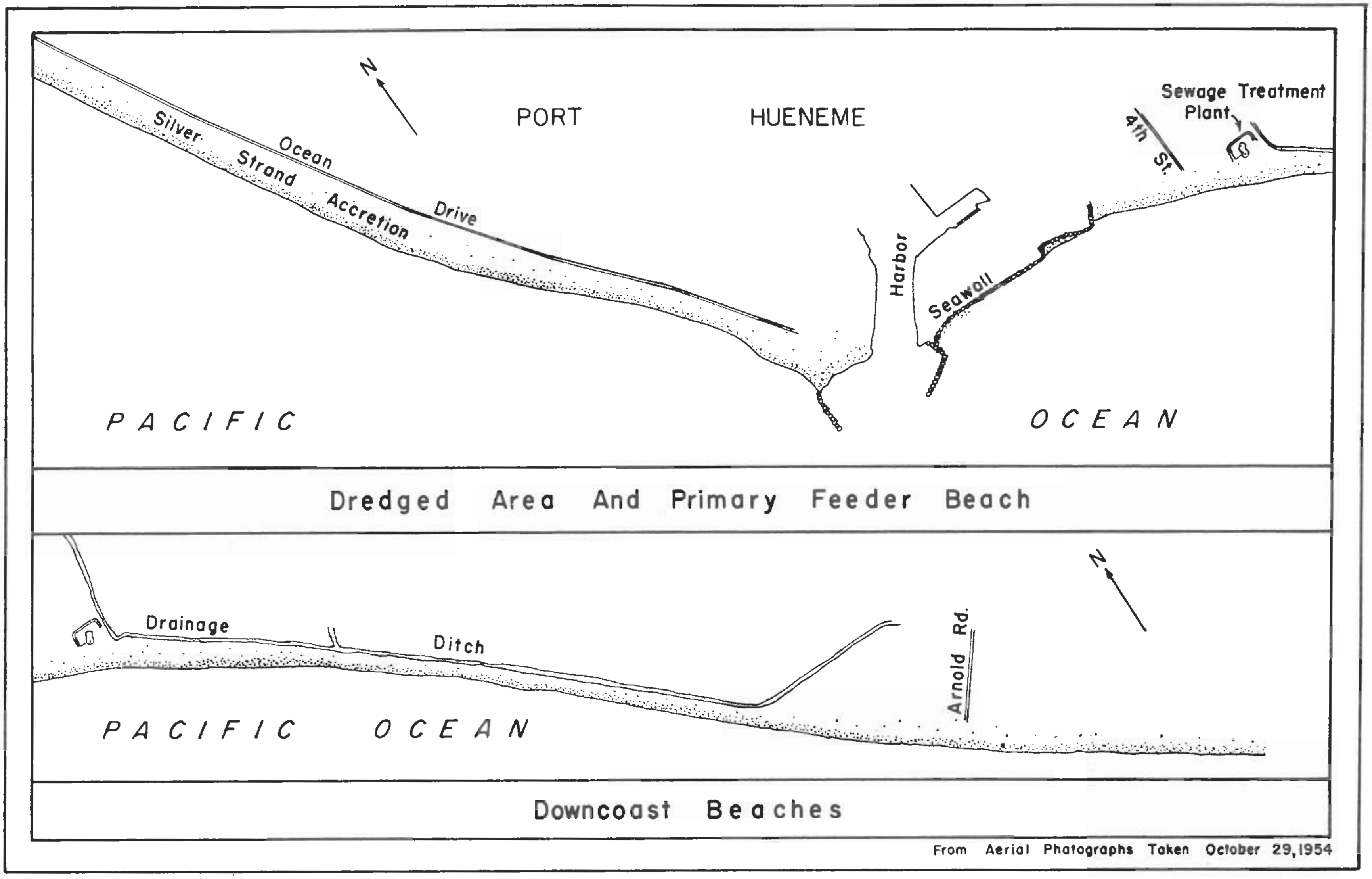

FIGURE 5. PORT HUENEME, CALIFORNIA. APPROXIMATE SHORE LINE FOUR MONTHS AFTER DREDGING.

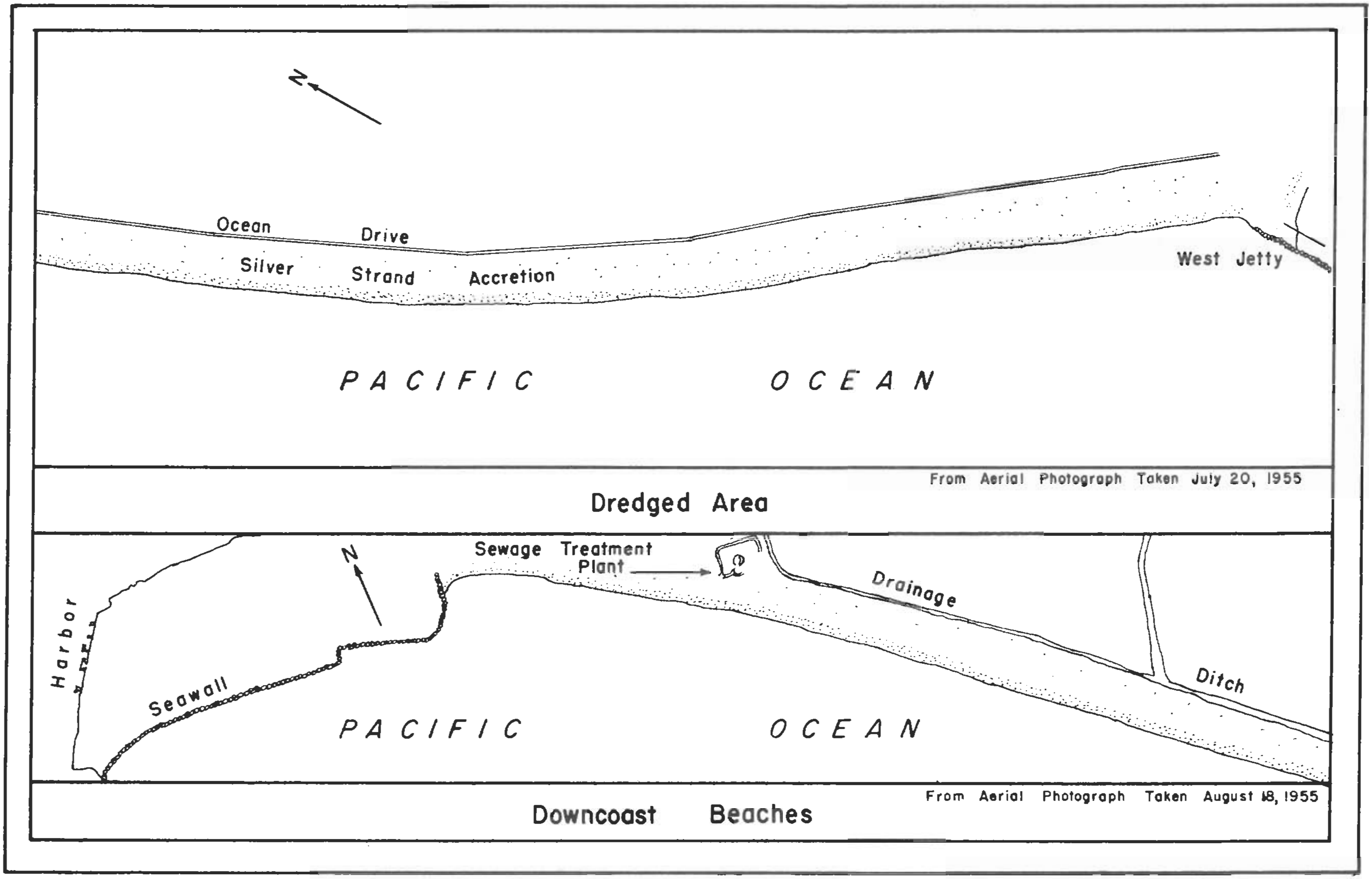

FIGURE 6. PORT HUENEME, CALIFORNIA. APPROXIMATE SHORE LINE ONE YEAR OR MORE AFTER DREDGING.

b. A total of approximately 1,400,000 cubic yards of material was lost from the primary feeder beach during the year from June 1954 to June 1955. This probably represents a figure which is larger than normal for the general beach because of wave reflections from the sea wall in this area.

c. A total of 415,000 cubic yards of material was lost from the downcoast beaches from June 1954 to June 1955. In view of past indications this rate is very small and may be modified somewhat by future measurements (see Addendum).

CONCLUSIONS

The main conclusions reached as a result of this study are:

1. In planning future operations of this type, entry into the dredging area should be made from any sheltered water body which provides a feasible entry route. The feasibility of an operation carried out in the same manner in an area of heavy wave action in which entry must be made from the sea is seriously doubted. In areas of mild wave action, entrance from the sea will most probably be feasible, but a sheltered entry route should be preferred.

2. On the basis of the difficulties and risks involved in the phase 2 dredging, it appears that future operations of this type (phase 2 as originally planned) will not be feasible unless: (a) some form of protection is provided, or (b) anticipated wave action is very mild, or (c) dredging equipment specially designed to operate in rough weather becomes available.

3. For areas of essentially unidirectional transport of littoral material and substantial wave action, a single cut at the updrift end of the protective sand ridge would appear to be more economical than complete dredging of the ridge. The ridge stub will then erode, with apparently slight if any chance of closure of the cut, the eroded material moving into the dredged lagoon. Indications are that this procedure also might be applicable in areas where the littoral drift movement is not unidirectional.

4. If filling of the dredged area continues at the rate indicated from completion of dredging to June 1955, the area will be re-filled before June 1957, except for that portion above high water where restoration of former height is dependent primarily upon wind transport.

5. Movement of the dredged material along the downcoast beaches at the rate indicated from dredging to June 1955 would cause erosion of the beaches of the Mugu Test Center by June 1959. However, on the basis of the June 1956 survey (note addendum) not yet completely analysed, it appears that the June 1959 date is probably optimistic. Using this longer period (June 1954-June 1956) as a basis of estimation it appears that erosion in the Test Center area will occur by June 1958.

ACKNOWLEDGMENTS

Much of the information contained in sections of this report covering the description and history of Port Hueneme, littoral forces and processes in the region, and plans for sand bypassing, was taken from reports prepared by the Los Angeles District of the Corps of Engineers.

The author appreciates the aid given by G. W. Simmons and H. P. VanEckhardt in the preparation of the material for this report, and the cooperation of the Los Angeles District in providing survey and dredging information, and of the Navy Civil Engineering Research and Evaluation Laboratory at Port Hueneme, in providing continuing photographic coverage of the area during and after the dredging operation.

ADDENDUM

Since the major part of the foregoing report was written, the June 1956 survey has been completed and a cursory examination of the results has been made. This survey indicates that the drift rate along the downcoast beaches has accelerated, losses from the harbor to range 26-E-18 for the period June 1955 to June 1956 being in the order of 2 million cubic yards. Indications on some profiles are that slight recession may already be occurring on the borders of the Mugu Test Center; indications generally from all profiles and the accelerated erosion rate over what had been experienced the previous year are that serious erosion may occur in this area by June 1958 (rather than by the June 1959 date estimated from the earlier data).

Filling of the dredged area north of the harbor has slowed considerably, presumably because the shore line has advanced enough to again feed a large portion of the drift into Hueneme Canyon.

It is anticipated that another hydrographic survey will be made in the Port Hueneme area in June 1957. The results of this survey and the June 1956 survey will then be analysed and a final report prepared on the Port Hueneme sand bypassing operation.

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4. Corps of Engineers, U. S. Army, "Santa Barbara Harbor, California", House Document No. 348, 77th Congress, 1941.

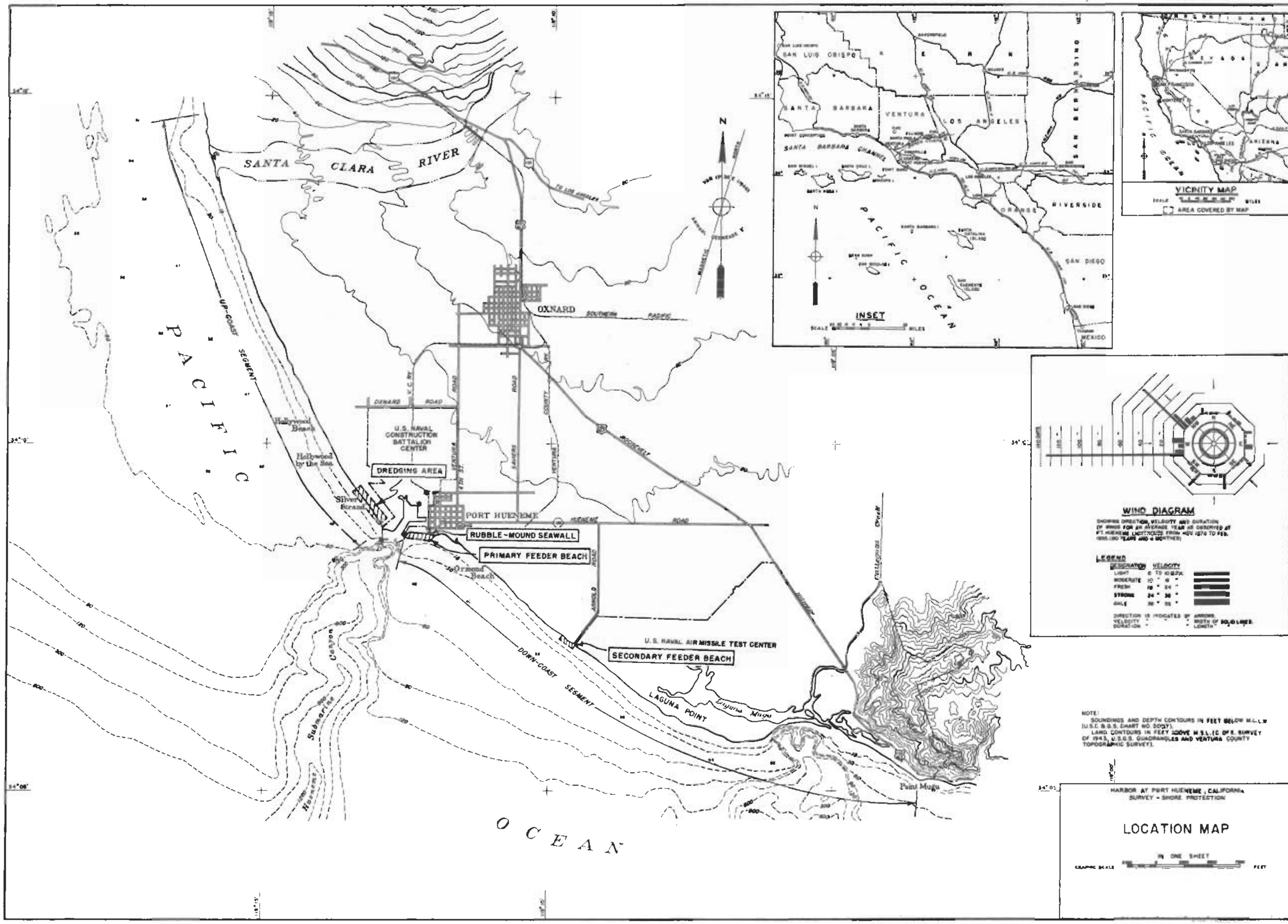
5. Corps of Engineers, U. S. Army, "Santa Barbara, California, Beach Erosion Control Study", House Document No. 761, 80th Congress, 1948.

6. Corps of Engineers, U. S. Army, "Port Hueneme, California", House Document No. 362, 83d Congress, 1954.

7. Scripps Institution of Oceanography, "A Statistical Study of Waves at Five Open Sea Localities on the California Coast", Wave Report No. 68, July 1947.

8. Corps of Engineers, U. S. Army, "Appendix I, Coast of California, Carpinteria to Point Mugu, Beach Erosion Control Study", House Document No. 29, 83d Congress, June 6, 1952.

9. Corps of Engineers, U. S. Army, "Letter Report on Shore Protection, U. S. Naval Air Missile Test Center, Point Mugu, California", 13 March 1953, Unpublished.


SANTA CLARA RIVER
PACIFIC
OCEAN
OXNARD
SOUTHERN PACIFIC
OXNARD ROAD
U.S. NAVAL CONSTRUCTION BATTALION CENTER
DREDGING AREA
Hollywood Beach
Hollywood by the Sea
Silver Strand
PORT HUENEME
HUENEME ROAD
RUBBLE-MOUND SEAWALL
PRIMARY FEEDER BEACH
Ormond Beach
UP-COAST SEGMENT
DOWN-COAST SEGMENT
U. S. NAVAL AIR MISSILE TEST CENTER
SECONDARY FEEDER BEACH
LAGUNA POINT
Laguna Mugu
Point Mugu
Submarine Canyon
Hueneme
INSET
SAN LUIS OBISPO
SANTA BARBARA
VENTURA
LOS ANGELES
SAN BERNARDINO
RIVERSIDE
ORANGE
SAN DIEGO
SANTA BARBARA CHANNEL
PACIFIC OCEAN
MEXICO
VICINITY MAP
AREA COVERED BY MAP
WIND DIAGRAM
LEGEND
DESIGNATION VELOCITY
LIGHT
MODERATE
FRESH
STRONG
GALE
HARBOR AT PORT HUENEME, CALIFORNIA
SURVEY - SHORE PROTECTION
LOCATION MAP
IN ONE SHEET

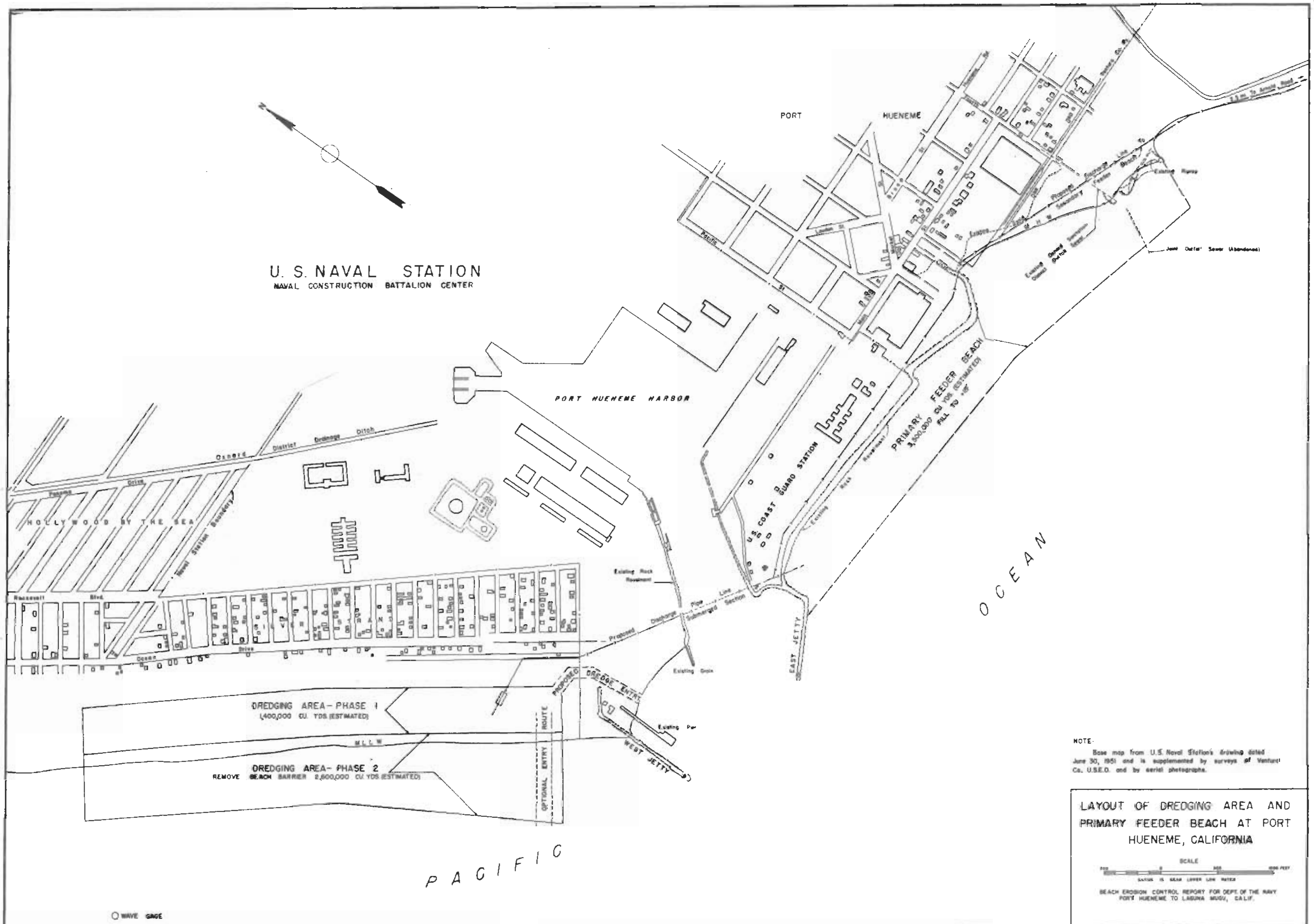
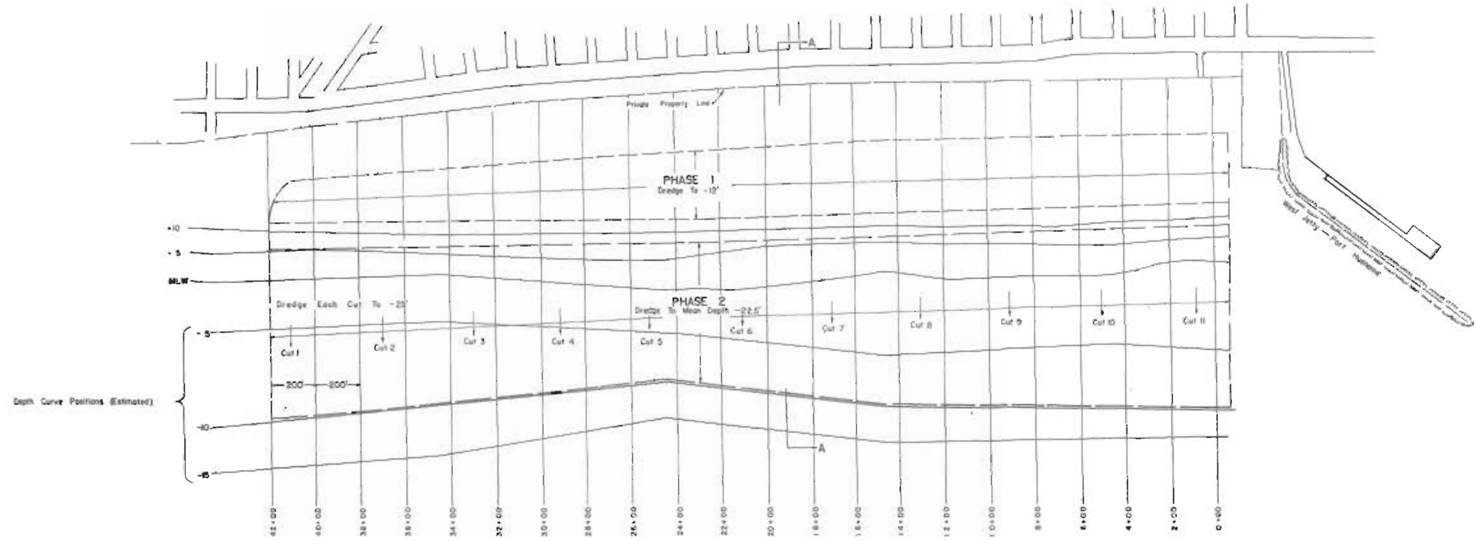
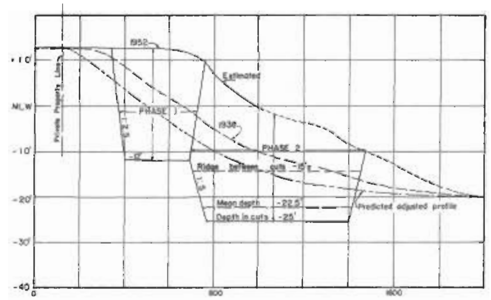

U. S. NAVAL STATION
NAVAL CONSTRUCTION BATTALION CENTER
PORT
HUENEME
PORT HUENEME HARBOR
HOLLYWOOD BY THE SEA
Oxnard District Drainage Ditch
Existing Rock Revetment
Proposed Discharge Pipe Line Submerged Section
Existing Groin
Existing Pier
U.S. COAST GUARD STATION
PRIMARY FEEDER BEACH
3,500,000 CU. YDS. (ESTIMATED)
FILL TO +18'
EAST JETTY
WEST JETTY
PROPOSED DREDGE ENTRY
OPTIONAL ENTRY ROUTE
DREDGING AREA - PHASE 1
1,400,000 CU. YDS. (ESTIMATED)
M.L.L.W.
DREDGING AREA - PHASE 2
REMOVE BEACH BARRIER 2,600,000 CU. YDS. (ESTIMATED)
OCEAN
PACIFIC
WAVE GAGE
NOTE-
Base map from U.S. Naval Station's drawing dated June 30, 1951 and is supplemented by surveys of Ventura Co., U.S.E.D. and by aerial photographs.
LAYOUT OF DREDGING AREA AND PRIMARY FEEDER BEACH AT PORT HUENEME, CALIFORNIA
SCALE
BEACH EROSION CONTROL REPORT FOR DEPT. OF THE NAVY
PORT HUENEME TO LAGUNA MUGU, CALIF.

PLATE 2



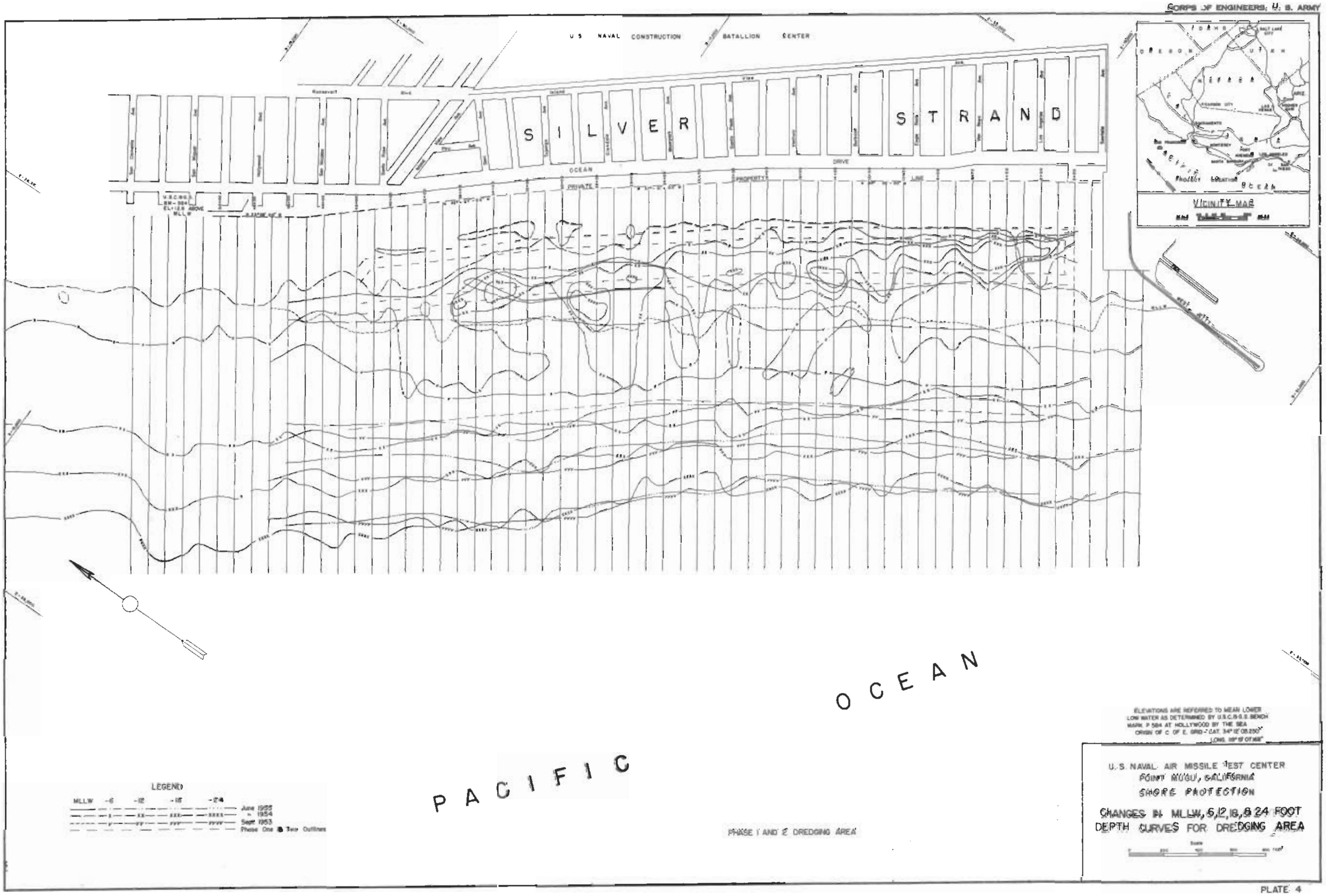
SUGGESTED DREDGING PLAN



SECTION A-A
Cross Section Of Phase1 And Phase 2 Dredging
And Predicted Adjusted Profile

SHORE PROTECTION, NAVAL AIR MISSILE
TEST CENTER, PT. MUGU, CALIFORNIA.
SUGGESTED PLAN FOR DREDGING ACCRETION AREA
NORTH OF PORT HUENEME

PLATE 3


CORPS OF ENGINEERS, U. S. ARMY
U S NAVAL CONSTRUCTION BATALLION CENTER
SILVER STRAND
OCEAN DRIVE
PRIVATE PROPERTY LINE
VICINITY MAP
PACIFIC OCEAN
LEGEND
MLLW -6 -12 -18 -24
June 1955
" 1954
Sept 1953
Phase One & Two Outlines
PHASE 1 AND 2 DREDGING AREA
ELEVATIONS ARE REFERRED TO MEAN LOWER LOW WATER AS DETERMINED BY U.S.C.&G.S. BENCH MARK P 584 AT HOLLYWOOD BY THE SEA
U. S. NAVAL AIR MISSILE TEST CENTER
POINT MUGU, CALIFORNIA
SHORE PROTECTION
CHANGES IN MLLW, 6,12,18,& 24 FOOT DEPTH CURVES FOR DREDGING AREA
PLATE 4

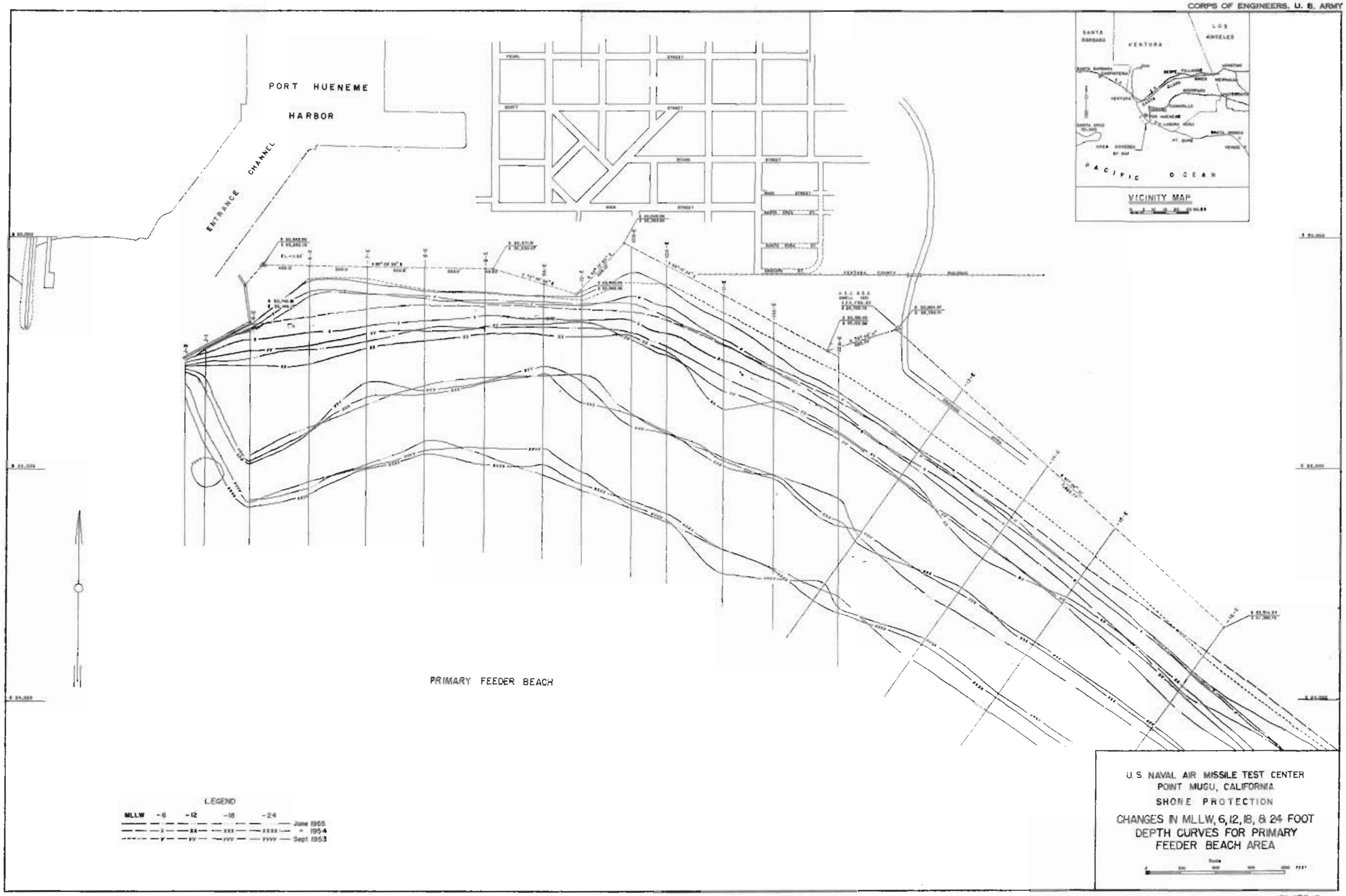

CORPS OF ENGINEERS, U. S. ARMY
PORT HUENEME
HARBOR
ENTRANCE CHANNEL
VICINITY MAP
SANTA BARBARA
VENTURA
LOS ANGELES
PACIFIC OCEAN
PRIMARY FEEDER BEACH
LEGEND
MLLW -6 -12 -18 -24
June 1955
1954
Sept. 1953
U.S. NAVAL AIR MISSILE TEST CENTER
POINT MUGU, CALIFORNIA
SHORE PROTECTION
CHANGES IN MLLW, 6, 12, 18, & 24 FOOT
DEPTH CURVES FOR PRIMARY
FEEDER BEACH AREA

PLATE 5

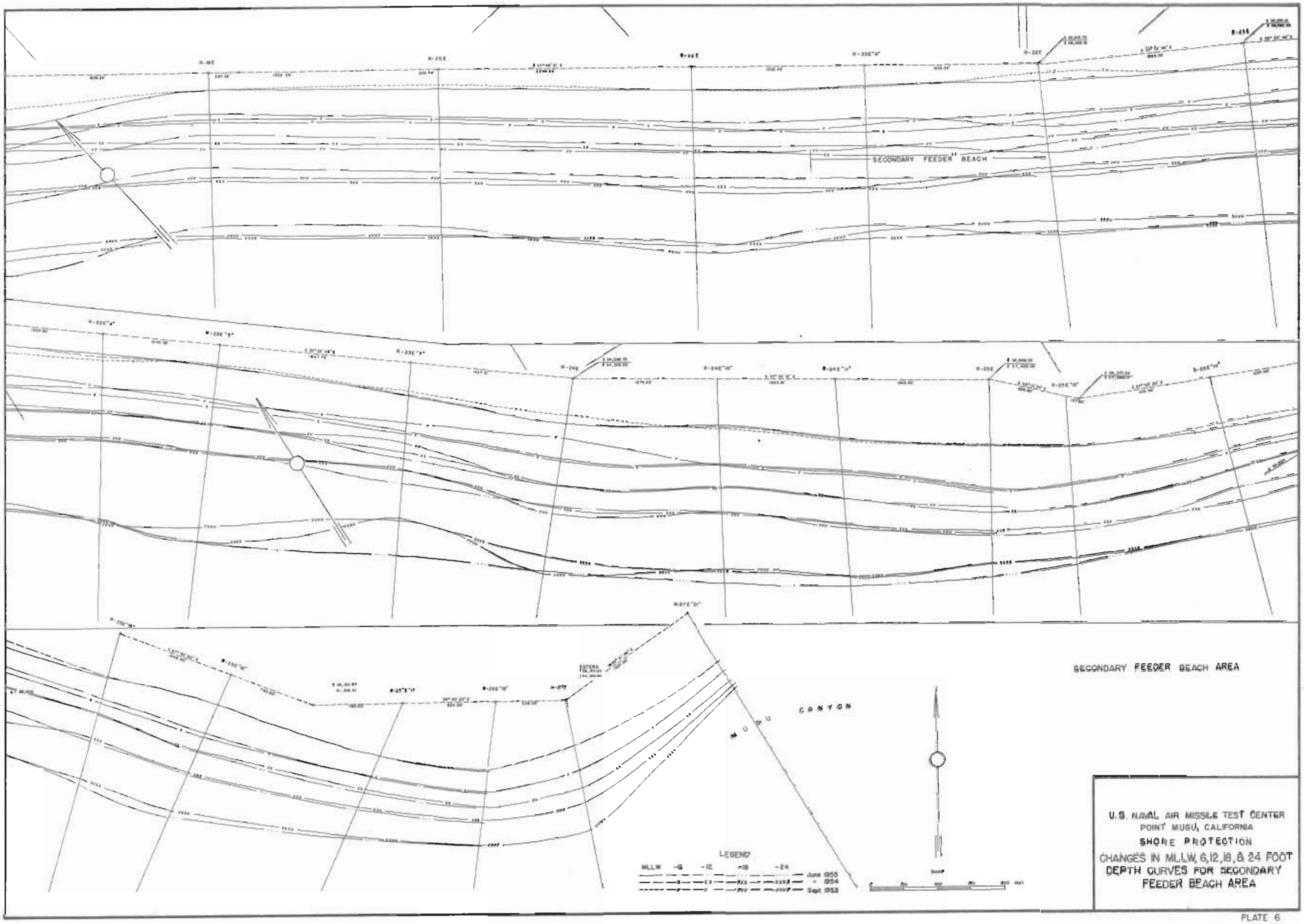

SECONDARY FEEDER BEACH
SECONDARY FEEDER BEACH AREA
MUGU CANYON
LEGEND
MLLW -6 -12 -18 -24
June 1955
" 1954
Sept. 1953
U.S. NAVAL AIR MISSILE TEST CENTER
POINT MUGU, CALIFORNIA
SHORE PROTECTION
CHANGES IN MLLW, 6, 12, 18, & 24 FOOT DEPTH CURVES FOR SECONDARY FEEDER BEACH AREA

PLATE 6

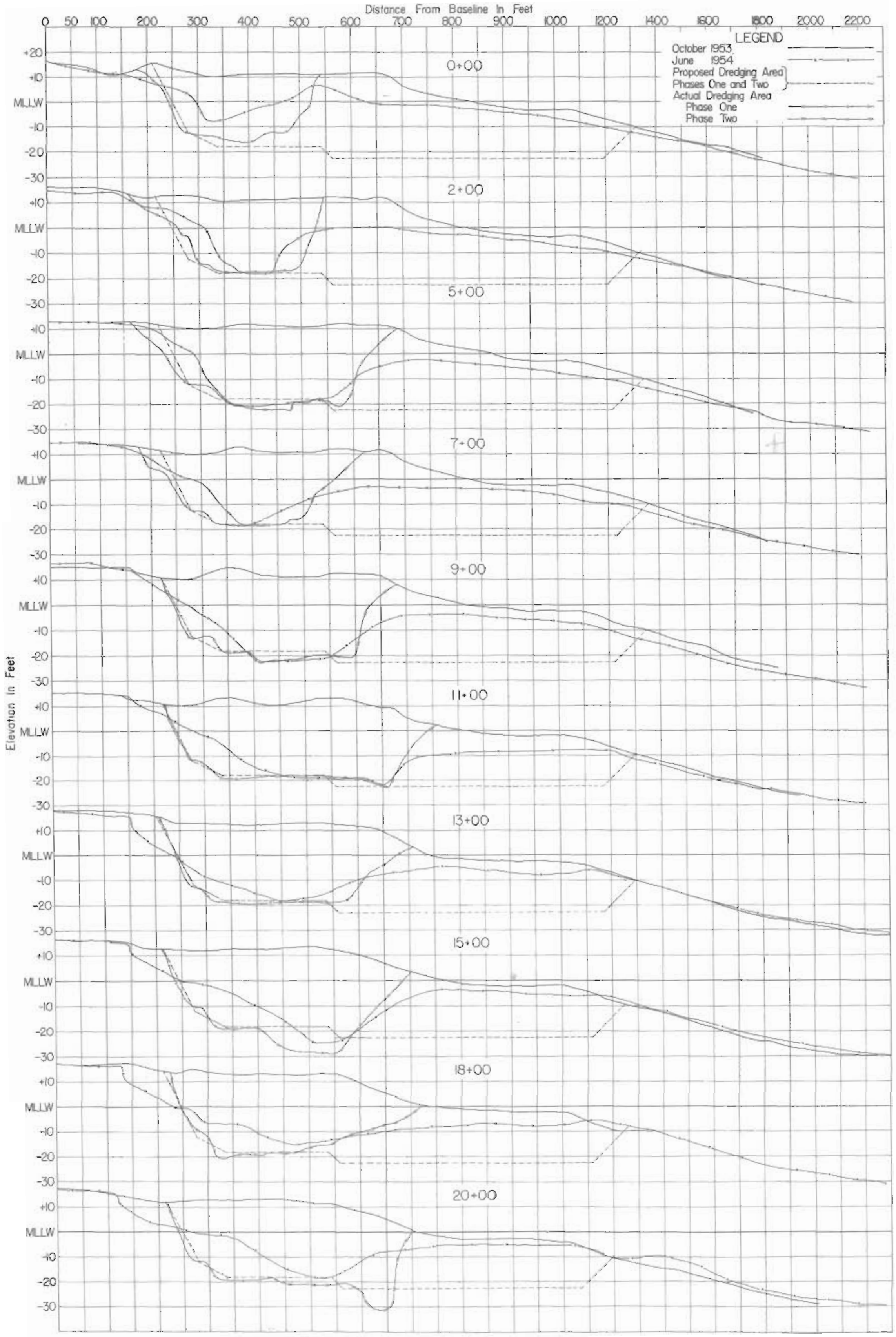


PLATE 7 PORT HUENEME, CALIFORNIA. COMPARATIVE PROFILES BEFORE, DURING, AND AFTER DREDGING OPERATIONS.

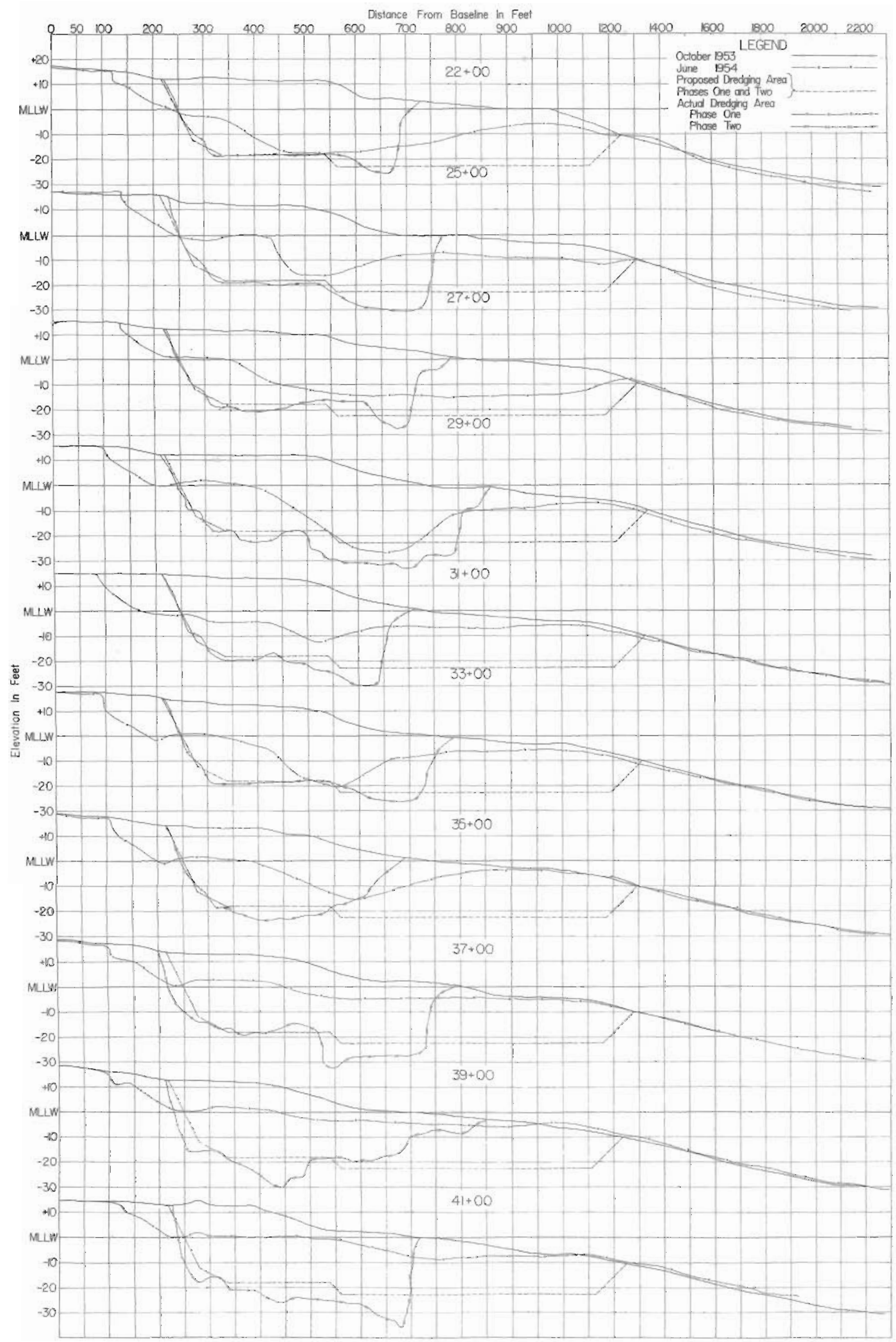


PLATE 8. PORT HUENEME, CALIFORNIA. COMPARATIVE PROFILES BEFORE, DURING, AND AFTER DREDGING OPERATIONS.

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